REPORT

DRAFT

WORK PLAN FOR UPPER BASALT ZONE 2 (UBZ-2) PHASE 2 - SOURCE AREA FIELD INVESTIGATIONS

Monsanto Soda Springs Idaho Plant

Submitted To: Monsanto Company
Soda Springs Plant
Highway 34
Soda Springs, ID 83276

Submitted By: Golder Associates Inc.
18300 NE Union Hill Road, Suite 200
Redmond, WA 98052 USA

Distribution:

3	Copies	Monsanto, Soda Springs, Idaho
1	Copy	EPA Region X, Seattle, Washington
1	Copy	IDEQ-Pocatello, Idaho
1	Copy	CH2M-Hill, Boise, Idaho
1	Copy	Stochos Environmental Inc.
2	Copies	Golder Associates Inc., Redmond, Washington

July 23, 2013 **913-1101-002.002.2G**

A world of capabilities delivered locally

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Acronyms and Abbreviations

Item	Definition
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRP	Conservation Reserve Program
IAC	Idaho Administrative Code
IC	Institutional Control
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality
IDWR	Idaho Department of Water Resources
ISM	Incremental Sampling Methodology
INW	Instrumentation Northwest
pCi/g	Picocuries per Gram
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SEM	Scanning Electron Microscopy
SPLP	Synthetic Precipitation Leaching Procedure
TCLP	Toxicity Characteristic Leaching Procedure
UBZ	Upper Basalt Zone
USBR	US Bureau of Reclamation
USEPA	US Environmental Protection Agency

1.0 INTRODUCTION

This Work Plan presents the purpose, scope and methods for the characterization of the potential source areas influencing the groundwater quality in the Upper Basalt Zone 2 (UBZ-2) and UBZ-1 at the Monsanto Soda, Springs Idaho Plant (Plant) site. The potential source areas were identified in Golder (2013) and include the following areas:

- Old Underflow Solids Ponds (extending into the UBZ-4 on the east side of the Monsanto Fault)
- Former coke and quartzite settling ponds (including former pond identified as “tailings pond” on historic maps, Golder 2012)
- Materials stockpiles
- Crushed slag
- An unidentified former disposal area

Based on the potential source areas, this Work Plan includes the field investigations and geochemical characterization that were recommended for the Old Underflow Solids Ponds, unidentified disposal area, and the “tailings pond” area (Golder 2013).

The source area characterization was requested by the US Environmental Protection Agency (USEPA) and the Idaho Department of Environmental Quality (IDEQ) following review of groundwater conditions and natural attenuation of the constituents of concern at the Plant site (CH2M Hill 2010). The characterization of the Old Underflow Solids Ponds and other potential source areas will provide information on the nature, extent and geochemistry of remaining underflow solids or other source materials, the geochemistry of the vadose zone and aquifer materials below the ponds, and groundwater quality in and downgradient of the potential source areas. This information will be used to evaluate the current source area concentrations of the constituents of concern (COC), the mechanisms for the release of constituents to groundwater, and the physical and geochemical controls on constituent migration.

This Work Plan is organized into the following sections:

- **Section 2** presents a brief background section that includes a brief description of the UBZ-2 source areas and existing groundwater and groundwater quality conditions
- **Section 3** present the approach to the field investigations
- **Section 4** describes the field investigations
- **Section 5** describes the geochemical characterization and groundwater quality analyses
- **Section 6** describes the data evaluation and reporting
- **Section 7** describes quality assurance and quality control (QC)

All work will be performed in accordance with State of Idaho monitoring well construction regulations (IDAPA 37.03.09, IAC 2010) included in Appendix A. Technical procedures and quality assurance/quality control procedures are presented in Appendices B and C.

2.0 BACKGROUND

The Monsanto Soda Springs Plant (Plant) is located one mile north of the City of Soda Springs, Caribou County, Idaho (Figure 2-1). The site covers an area of approximately 800 acres, with the fenced Plant site accounting for 540 acres.

Monsanto purchased agricultural land in 1952 to construct the Soda Springs elemental phosphorus production plant. The Plant uses locally mined phosphate ore. In 1984, Golder Associates Inc. (Golder) was retained to assess the impact of operations on groundwater and surface water quality at the Plant. The 1984 study found elevated concentrations of cadmium, selenium, fluoride and sulfate in groundwater beneath the Plant (Golder 1985). The sources of these constituents were determined to be the Old Underflow Solids Ponds, the Northwest Pond, and the Old Hydroclarifier. The investigation also concluded that groundwater under the southeastern portion of the plant contained elevated concentrations of vanadium, chloride, and sulfate. Based on groundwater flow directions and geochemical data, the elevated concentrations of these constituents in the southeastern portion of the Plant were attributed to the former Kerr-McGee Chemical Corporation (now Tronox) facility located to the east of the Plant, across Highway 34 from the Plant, and was further supported by findings from a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site inspection conducted in 1988 and supported by the results of the Remedial Investigation/Feasibility Study (RI/FS) activities completed at the Plant (Golder 1992, 1995).

Monsanto conducted and submitted to the USEPA a Phase I RI in 1992 (Golder 1992) and a Phase II RI in 1995 (Golder 1995). A Record of Decision (ROD) was signed by Monsanto and the USEPA in 1997. The selected remedy for groundwater is monitored natural attenuation. Bi-annual groundwater monitoring was in place from 1991 to 1998, and annual groundwater monitoring has occurred since 1998. Annual groundwater, surface water, and non-contact cooling water discharge monitoring is conducted at and near the Plant in order to ensure that natural attenuation is proceeding per modeled predictions (Golder 2003, 2008), and to monitor the natural attenuation process. Annual groundwater and surface water quality reports are prepared following completion of the annual sampling to evaluate groundwater quality and short-term groundwater quality trends. Long-term groundwater and surface water quality trends are statistically evaluated as part of the Five-Year Review process (Golder 2003, 2008).

An evaluation of natural attenuation in the UBZ-2 was completed in 2009 (Golder 2011). The evaluation of natural attenuation indicated that concentrations of cadmium, fluoride, and manganese are controlled by the precipitation of mineral phases (otavite, fluorite, and rhodochrosite, respectively). Cadmium concentrations are also affected by the presence of chloride. As chloride concentrations increase, the formation of cadmium-chloride complexes occurs and cadmium is remobilized. Increasing chloride concentrations as a result of runoff and infiltration of dust suppression chemicals (specifically magnesium chloride) has been observed in UBZ-2 at monitoring well TW-37 (Golder 2011).

Concentrations of nitrate and selenium in UBZ-2 are not controlled by mineral precipitation. These constituents are transported conservatively and concentrations of these constituents are affected by limited dispersion only.

2.1 Potential UBZ-2 Source Areas

The potential UBZ-2 source areas are shown in Figure 2-2. The primary sources in UBZ-2 are believed to be remnant materials remaining in the Old Underflow Solids Ponds following closure and secondary minerals precipitated in the vadose zone below the ponds. The Old Underflow Solids Ponds were developed primarily in UBZ-2, with a small portion of the ponds extending across the Monsanto Fault to UBZ-4. The Old Underflow Solids Ponds were unlined ponds used to dewater underflow solids. The ponds were closed in 1987 by excavating most of the remaining underflow solids and filling the ponds with molten slag. The ponds were then capped with bentonite and crushed slag. About 35,000 tons of materials remained in the ponds following closure. These remnant materials appear to be above the water table based on the estimated pond depths and groundwater elevations in nearby wells (Golder 2013).

There is a former “tailings” pond located south of the Old Underflow Solids Ponds and north of the coke and quartzite settling ponds (Figure 2-2) that appears to be a potential source area. There is no information on the closure of this pond however it appears to be out of service by 1970 (Golder 2013).

Historic maps show and area north of the Old Underflow Solids Ponds as an unidentified disposal area based on anecdotal evidence (Golder 1995). There is no information on what may have been placed in this area. This area is currently an area where crushed slag has been placed as fill.

There are some material stockpiles in UBZ-2 including crushed slag, slag placed as molten material, sand, cinders, and clean soils. These materials are not significant sources of groundwater contamination because of the low concentrations of constituents of concern (Golder 1995). Treater dust and nodules are also stockpiled in the UBZ-2. These materials may be potential sources of fluoride based on the geochemical characterization (Golder 2013).

There are also former source areas in the UBZ-1 and UBZ-4 adjacent to the UBZ-2. The UBZ-1 source areas including the former coke and quartzite ponds, former non-contact cooling water (effluent) setting pond, and former sewage evaporation ponds, are all downgradient of the UBZ-2 source areas and were all closed in the late 1980s and early 1990s. Slag stockpiles in UBZ-1, either crushed slag or material originally placed as molten slag, are not a potential source of groundwater contamination (Golder 1995).

While there are documented sources of contamination in the UBZ-4 including the Northwest Pond, Old Hydroclarifier, and a small portion of the Old Underflow Solids Ponds that are primarily developed in UBZ-2, affected groundwater is captured by the Plant Production wells. The ore stockpiles and underflow solids piles in UBZ-4 may be potential source areas; however, there is no evidence that they are affecting groundwater. Groundwater flow from source areas in the UBZ-4 to UBZ-2 are interpreted to be minor because of the hydraulic barrier created by the Monsanto Fault in the area of the Old Underflow Solids Ponds.

2.2 Hydrogeology

The geologic units in the UBZ-2 consist of a series of low-permeability basalt flows and interbedded, higher permeability interflow zones consisting of cinders, rubbly basalt, and sedimentary materials. There is some vertical hydraulic communication between interflow zones particularly within the UBZ. The basalt is overlain by unconsolidated sediments and fill materials.

Two faults border the UBZ-2; the Monsanto Fault on the east side and the Subsidiary Fault of the west side. Both faults are hinge faults with variable offset along strike; thus the hydraulic nature of the faults is variable along strike. The Monsanto Fault appears to act as at least a partial hydraulic barrier between UBZ-2 and UBZ-4 in Plant area near the Old Underflow Solids Ponds based on groundwater elevation differences across the fault and lack of response to pumping of the Plant Production Wells on the west side of the fault.

The Subsidiary Fault appears to act as a partial barrier to groundwater flow south and west of the Old Underflow Solids Ponds, allowing some flow of groundwater from UBZ-2 to UBZ-1 based on groundwater quality data in well TW-69 and Southwest Spring. At the Plant fenceline, the Subsidiary Fault acts as a hydraulic barrier (Golder 1995).

The hydraulic conductivity of UBZ-2 is locally highly variable depending on the thickness of the interflow zones and the type of materials in the interflow zones. The hydraulic conductivity is estimated to range from about 1 to 1,000 feet per day (ft/d) based on falling-head and pumping tests. The groundwater velocity is estimated to range from about 1 to 2 ft/d based on passage of peak concentration trends in wells downgradient of the Old Underflow Solids Ponds. The hydraulic conductivity in UBZ-2 was estimated to range from about 33 to 220 ft/d based on the estimated groundwater velocity and an assumed effective porosity of 30%.

Groundwater elevations in areas of UBZ-2, including wells near the Old Underflow Solids Ponds, appear to have increased about 2 to 3 feet since about 2003 despite near-average precipitation. Groundwater levels also respond over the short-term in response to changes in precipitation. Groundwater flow in UBZ-2 is to the southeast in the Plant area and to the south in the area south of the South Plant Fence

Fine. There is a downward component of vertical hydraulic gradient near the Old Underflow Solids Ponds. At the South Plant Fence Line in UBZ-2, there is an upward component of vertical hydraulic gradient. South of the south Plant fenceline, there is a downward component of vertical hydraulic gradient in the UBZ-2.

3.0 INVESTIGATION APPROACH

The USEPA requested that Monsanto characterize the source areas in UBZ-2 in order to:

- Evaluate the geological and hydrogeological conditions in UBZ-2 and UBZ-4 near potential source areas.
- Evaluate the geochemical conditions in the vadose zone and UBZ-2 aquifer in the Old Underflow Solids Ponds area and other areas of UBZ-2 and UBZ-4 adjacent to the Monsanto Fault.
- Evaluate the infiltration rates through the Old Underflow Solids Ponds cap.
- Evaluate the presence of residual underflow solids in the Old Underflow Solids Ponds area.
- Evaluate other potential source areas and the presence of residual materials in the UBZ-2.

To meet these goals, the following approach is proposed:

- Phase 1 – Review of Existing Information:
  - Review of available information for the hydrogeologic conditions and potential source areas in UBZ-2, including operation and closure information, and existing sampling and characterization data.
  - The results of the Phase 1 information review are reported in Golder (2013).
- Phase 2 – Field Investigations and Analysis:
  - Excavation of test pits in order to collect samples of potential source materials and characterize the extent of the “tailings pond” identified in the Phase evaluation.
  - Drill boreholes in order to characterize the geologic units and collect samples of the subsurface materials, including remnant source materials, vadose zone materials, and aquifer materials, in the Old Underflow Solids Ponds area, “tailings pond” area, unidentified disposal area, and areas on the east side of the Monsanto Fault (UBZ-4).
  - Installation of monitoring wells in the boreholes and collection of groundwater quality samples to characterize the groundwater quality in and downgradient of the source areas.
  - Groundwater level monitoring to evaluate groundwater elevation trends, response to pumping of the Plant Production wells, and to evaluate the hydraulic characteristics of the Monsanto Fault.
  - Geochemical characterization on selected samples to determine potential controls on constituent release and migration including:
    - Elemental analyses to evaluate the bulk chemistry of source, vadose zone, and aquifer materials.
    - X-ray diffraction analysis on selected samples to evaluate mineralogy.
    - Leach tests to evaluate constituent release.
- Phase 3 – Data analysis, interpretation and reporting the results of the investigations.

4.0 FIELD INVESTIGATIONS

Test pits will be excavated and boreholes will be drilled in the area of the Old Underflow Solids Ponds and other UBZ-2 potential source areas and in UBZ-4 east of the Monsanto Fault to characterize subsurface conditions and to collect samples of the geologic materials in the vadose zone and below the water table and any remnant underflow solids for geochemical characterization. Monitoring wells will be installed in the boreholes to provide information on groundwater quality in and downgradient of the source areas and groundwater elevation.

4.1 Test Pitting

Test pits will be excavated in the area of the “tailings pond” north of the coke and quartzite settling ponds (Figure 4-1). Seven test pits (TP-1 through TP-7, inclusive) will be excavated to evaluate the lateral extent of the materials deposited in the “tailings pond”, the thickness of the materials, and to provide samples for visual logging and geochemical characterization. The test pit locations are summarized in Table 4-1. The test pit locations are approximate and will be confirmed in the field based on access considerations. The test pits will be located using a handheld GPS prior to excavation.

The test pits will be excavated by an excavator or backhoe supplied and operated by Monsanto. The test pits will be excavated to a depth of 10 to 15 feet below ground depending on the capacity of the equipment and the stability of the pits.

The test pits will be logged in accordance with Technical Guideline TG-1.2-21 *Technical Guide for Geotechnical Test Pit Logging* (Golder 2007) and photographed. Any shallow seepage or damp materials will be noted. If there is sufficient seepage for sampling, a water quality sample will be collected if it can be safely collected. Samples of the materials excavated in the pits will be collected from the excavator bucket or spoils pile for geologic logging and geochemical analysis. It is anticipated that the following samples will be collected in each pit:

- Two to four samples will be collected of potential source materials in each pit depending on the thickness and nature of the materials.
- Two samples will be collected from native materials below the potential source materials if the pit can be excavated to sufficient depth.

Samples collected for geochemical analysis will be removed from the excavator bucket or spoils pile using a stainless steel trowel or spoon and placed in appropriate sample containers in accordance with Technical Procedure TP-1.2-18 *Sampling Surface Soils for Chemical Analysis (*Golder 1996a). All samples will be stored at 4°C.

The completed test pits will be backfilled with the excavated materials and tamped. The excavator bucket will be cleaned with a shovel and brush between test pits. A high-pressure water (steam) cleaner will be used to decontaminate the bucket between test pits. The sampling trowel or spoon will be decontaminated with brush, Alconox wash, and distilled/deionized water rinse between each sample. The final test pit locations will be surveyed using a hand-held GPS unit.

4.1.1 Test Pit Sampling

Samples for geochemical characterization will be collected from the test pits based on the materials intersected in each pit. Samples will be collected and stored in accordance with Golder Technical Procedure TP-1.2-18 *Sampling Surface Soil for Chemical Analysis* (Golder 1996a).

Samples for geochemical analysis will be selected for analyses based on lithology, depth, material type, and presence of residual underflow solids or other potential source materials. The analyses will include:

- Geochemical characterization of metals and major elements.
- Leach testing:
  - TCLP testing in "tailings pond" area samples that have not been previously tested by Monsanto.
  - SPLP testing using a 4:1 solution to solid ratio.
  - Groundwater leach testing, including spiking with magnesium chloride to evaluate cadmium solubility with increasing chloride concentrations.
- Mineralogical characterization (to be refined following geochemical characterization and leach testing):
  - X-ray diffraction (with Reitveld refinement).
  - Microscopic evaluation or Scanning Electron Microscopy (SEM).

Additional details on the geochemical characterization are provided in Section 5. All samples will be stored and transported on ice under Chain-of-Custody according to Golder Technical Guideline TG-1.2-23 *Chain of Custody* (Golder 2009a).

4.2 Borehole Drilling

Nine boreholes will be drilled to characterize subsurface conditions in the former source areas, provide samples of materials from the former source areas, vadose zone materials underlying the source areas, and from the UBZ aquifer, and to install monitoring wells in and downgradient of the former source areas. The boreholes are designated TW-71 through TW-79; inclusive.

The boreholes will be drilled at the proposed locations shown in Figure 4-1. The actual borehole locations will be confirmed following a field survey of access and safety considerations and long-term plans for Plant stockpiles including the molten slag pile. The boreholes will be advanced to a depth of about 100 to 120 feet below ground, or about 10 to 20 feet below the water table (Table 4-1). The final depth will be determined based on the conditions encountered in each borehole.

An Idaho-licensed and qualified drilling contractor will drill and complete the boreholes. The boreholes will be drilled and completed in accordance with the Idaho Administrative Procedures Act for Well Construction Standards Rules (IDAPA 37.03.09; IAC 2010), and in accordance with Golder Technical Procedure Technical Procedure TP 1.2-3, *Drillhole Logging for Rotary/Cable Tool Drilling* (Golder 1996b) and TP-1.2-5 *Drilling, Sampling, and Logging of Soils* (Golder 1996c). Copies of the Idaho well construction regulations are included in Appendix A, and technical procedures for borehole drilling and sampling are included in Appendix B for reference. Permits ("start cards") will be obtained from the Idaho Department of Water Resources (IDWR) prior to borehole drilling. The contractor will file well logs and any other required information with IDWR at the completion of drilling.

The boreholes will be drilled using either a reverse-circulation, air-rotary drilling rig equipped with a casing advancing system capable of advancing casing in basalt bedrock (under-reamer or dual-rotary system) or a possibly a sonic drill rig depending on contractor availability and ability of a sonic rig to successfully penetrate the basalt bedrock. The final borehole diameter will be a minimum of 8 inches in order to install a 4-inch diameter monitoring well.

Formation samples (cuttings) will be collected every five feet, from shorter intervals of unique materials, or at formation changes and geologically logged during drilling. The following will be noted:

- Depths and lithology of materials intersected, including potential source or cap materials.
- Drilling advance rate.
- Rock structure (fractured, dense, etc.).
- Depth(s) of seepage or groundwater-bearing zones intersected.
- Qualitative water content (dry, damp, moist, wet).
- Air-lift flow rate in groundwater-bearing zones (if possible).
- Drilling action and zones of lost circulation, fracturing, changes in drilling advance rate, etc.
- Groundwater level at time of drilling, if possible to measure.

If air-rotary drilling is used, grab samples will be collected from the cuttings return and split onsite. One sample will be used to geologically log the borehole and will be archived. The second sample will be used for geochemical characterization.

Field groundwater quality parameters (temperature, pH, and conductivity) will be periodically measured in any groundwater airlifted from water-bearing zones.

Borehole infiltration testing (using an approved water source) will be conducted in boreholes drilled into the Old Underflow Solids Ponds caps to evaluate the infiltration rates through the cap materials (poured slag and bentonite). This includes boreholes TW-71, TW-72, and TW-77. The testing will be performed in accordance with United States Bureau of Reclamation (USBR) Procedure 7310 – Constant Head Hydraulic Conductivity Tests in Single Drill Holes (USBR 1990). A copy of USBR Procedure 7310 is included in Appendix B. One test in the bentonite cap will be performed in each borehole, and two to three tests will be performed in the poured slag in each borehole.

If any boreholes are not completed as wells, they will be decommissioned in accordance with IDAPA 37.03.09 (IAC 2010).

4.2.1 Materials Characterization

Samples for geochemical characterization will be collected from the boreholes at 5-foot intervals, or from shorter intervals of unique materials, during drilling. Samples will be collected and stored in accordance with Golder Technical Procedure TP-1.2-18 *Sampling Surface Soil for Chemical Analysis* (Golder 1996a; Appendix A).

Sample intervals for geochemical analysis will be selected for analyses based on lithology, depth, and location above or below the water table, material type, and presence of residual underflow solids or other potential source materials. The analyses will include:

- Geochemical characterization of metals and major elements.
- Leach testing:
  - TCLP testing in "tailings pond" area samples that have not been previously tested.
  - SPLP testing using a 4:1 solution to solid ratio.
  - Groundwater leach testing, including spiking with magnesium chloride to evaluate cadmium solubility with increasing chloride concentrations.
- Mineralogical characterization (to be refined following geochemical characterization and leach testing):
  - X-ray diffraction (with Reitveld refinement).
  - Microscopic evaluation or Scanning Electron Microscopy (SEM).

Additional details on the geochemical characterization are provided in Section 5. All samples will be stored and transported on ice under Chain-of-Custody according to Golder Technical Guideline TG-1.2-23 *Chain of Custody* (Golder 2009a).

4.2.2 Monitoring Well Installation

Monitoring wells will be installed in each of the boreholes in accordance with Technical Guideline TG-1.2-12 *Monitoring Well Drilling and Installation (Rev. #8)*, (Golder 2009b). The monitoring wells will be completed using 4-inch diameter, flush-threaded, Schedule 40 PVC risers and well screens. The screened intervals in each well will be in the first water-bearing interflow zone in the UBZ. Centralizers will be placed on the top and bottom of the well screen, and at 40-foot intervals on the riser to centralize the well during installation. If necessary, the borehole will be backfilled below the selected screened section with 3/8-inch sodium bentonite chips or pellets to the desired completion interval. Wells will be completed with a silica sand filter pack, bentonite pellet seal, and a bentonite chip or bentonite grout annular seal. Temporary casing (if used) will be withdrawn as the annular materials are placed.

Following completion of well installation, the wells will be developed by air-lift pumping and surging, pumping and surging with a temporary pump, or swabbing and bailing. A permanent ½-hp submersible pump and dedicated riser and valve assembly will be installed in each well following air-lift development to further develop the well and for subsequent groundwater sample collection. Field water quality parameters (pH, specific conductance, turbidity, redox potential, temperature, and dissolved oxygen) will be measured during development. Well development will take place until water is free of material (e.g., cuttings and geologic materials), representative of formation water, and the turbidity is less than 5 NTU. Development water will be contained and disposed in the phossy water pond.

A locking protective monument, protective posts (if needed), and concrete pad will be installed following well completion and development. Typical monitoring well construction is shown in Figure 4-2. If a borehole is abandoned prior to well construction, it will be decommissioned in accordance with IDAPA 37.03.09 (IAC 2010).

A permanent measuring point will be designated on the top of each well riser or well seal. The new wells will be surveyed for location, ground elevation, and measuring point elevation (to the nearest 0.01 foot) following installation and will be tied into the current monitoring well network.

4.2.2.1 Borehole Decommissioning

At the completion of drilling, or in the event a borehole cannot be advanced to the desired depth, selected boreholes may be decommissioned by pressure grouting the borehole from the bottom up using high-solids bentonite grout. Any temporary casing will be removed and a concrete cap will be placed over the borehole. The borehole location will be staked for surveying.

4.2.3 Drilling Water and Decontamination

Water from PW-04, an upgradient (Background) production well will be used for drilling and borehole decommissioning. PW-04 is located at the north end of the Plant and is not affected by Plant activities. Alternatively, the driller may provide water from the City of Soda Springs municipal supply. Depending on the drilling method used, water may be introduced during drilling if needed to control dust or assist in cuttings return. Drilling foam may be needed to assist in cuttings return depending on borehole conditions. Any drilling foam used will be NSF-approved, and will be removed during development and prior to groundwater quality sampling.

All down-hole equipment (temporary drive casing, drill bits, samplers, drill rods, airlift tools, bailers, and water level indicators) shall be thoroughly cleaned upon arrival at the site and between boreholes with a high-pressure, high temperature, jetted stream of potable water and an approved detergent (Alconox) followed by a clean rinse. Decontamination will be conducted at a decontamination area designated by Monsanto within the Plant site. Only approved drilling lubricants specifically designed for monitoring wells (vegetable oil-based or Teflon grease) will be used for all downhole equipment to prevent the introduction of petroleum hydrocarbons.

4.3 Rising Head Tests

Rising head tests will be completed in the new monitoring wells in order to estimate the hydraulic conductivity of the completion interval by displacing water in the well using a bailer, slug, or the dedicated pump and rapidly recording water levels as they recover. The well will be pumped for 30 to 45 seconds using the sampling pump, a slug of water will be removed with a bailer, or displaced with a slug rod, and the water level recovery will be monitored using an automated pressure transducer and datalogger. Once the water level has re-equilibrated, a second test will be performed. The resulting data will be processed and analyzed using appropriate curve matching or straight-line methods.

Rising head tests will be conducted in accordance with Golder Technical Procedure TP 1.2-17 *Rising Head Slug Test* (Golder 1986).

4.4 Groundwater Quality Sampling

A groundwater quality sample will be collected in all of the new monitoring wells following well development and rising head tests. The wells will be purged for a minimum of three well volumes, until the turbidity is less than 5 NTU, and until field parameters (pH, conductivity, temperature, turbidity, redox potential, and dissolved oxygen) are stable. Purge water will be contained and disposed in the phossy water pond.

The groundwater quality samples will be collected and analyzed in accordance with procedures outlined in the Groundwater and Surface Water Sampling Work Plan (Golder 2012), Golder Technical Guideline TG-1.2-20 *Collection of Groundwater Quality Samples* (Golder 2009c) and Golder Technical Guideline TG-1.2-23 *Chain of Custody* (Golder 2009a). At least one duplicate sample and one split sample will be collected during sampling of the new wells. Table 4-2 summarizes the constituents that will be analyzed.

The new monitoring wells will be included in the annual groundwater monitoring program.

4.5 Groundwater Level Monitoring

Groundwater levels will be measured during drilling and development using an electric water level tape. Following completion of the monitoring wells, pressure transducers and dataloggers will be installed for long-term water groundwater level monitoring and evaluation of potential response to pumping of the Plant Production wells in order to characterize the hydraulic behavior of the Monsanto Fault.

The pressure transducers and dataloggers will be Instrumentation Northwest (INW) unvented PT2X, 30 psi sensors. An INW barometric pressure sensor and datalogger (PT2X-BV) will be installed in one of the well monuments to record barometric pressure in order to correct the groundwater level data for barometric pressure fluctuations. The dataloggers will be set to measure and record water levels hourly at the same time in order to correct for barometric pressure fluctuations.

5.0 GEOCHEMICAL CHARACTERIZATION AND GROUNDWATER QUALITY

Samples for geochemical analysis will be collected from the boreholes at 5-foot intervals during drilling, and from selected depths in test pits. Samples will be collected and stored in accordance with Golder Technical Procedure TP-1.2-18 *Sampling Surface Soil for Chemical Analysis* (Golder 1996b; Appendix A). Groundwater quality samples will be collected from the new monitoring wells in accordance with Golder Technical Guideline TG-1.2-20 *Collection of Groundwater Quality Samples* (Golder 2009c). All solids and groundwater samples will be stored and transported on ice under Chain-of-Custody according to Golder Technical Guideline TG-1.2-23 *Chain of Custody* (Golder 2009a).

5.1 Solids Geochemical Characterization

The geochemical characterization of the soils and geologic materials, remnant source materials and vadose zone materials collected in the source area boreholes and test pits will follow a phased approach as outlined in Table 5-1. Elemental analysis will be performed on samples collected from test pits and source area boreholes along a vertical profile through the source area and underlying vadose zone. At a minimum, elemental analyses will be performed on one sample of each representative material from each exploration (i.e. soil and/or fill materials, potential source materials, and native materials below any sources).

Characterization of the elemental composition of a sample is typically a two-step process that includes an acid digestion to release elements into the solution phase followed by analysis of the elements in the resulting digestion. Metals analysis will be conducted following USEPA Method 3050b (USEPA 1996). The analytical suites for the constituents are listed in Table 5-2.

Samples will be selected for leach testing and mineralogical analysis based on the type(s) and thickness of source materials intersected in the exploration, the results of the elemental analyses, and availability of previous geochemical characterization data (such as Golder 1995). Golder will prepare a technical memorandum summarizing the results of the source area explorations and elemental analyses and recommending samples for additional characterization. The memorandum will be submitted to EPA and IDEQ for review and concurrence on the proposed additional testing.

The additional geochemical characterization will include all or part of the following testing depending on the materials intersected in the explorations:

- **Leach Testing** – Leach testing will be conducted following standard USEPA protocols (i.e. SPLP and TCLP). A site-specific methodology will also be developed to evaluate leaching following interaction of vadose zone solids with site groundwater and site groundwater spiked with magnesium chloride in order to develop cadmium solubility controls. Leach test methods are listed below. The analytical suites for leachates are listed in Table 5-2.

- **Toxicity Characteristic Leaching Procedure (TCLP)** – The TCLP leach test (Method 1311, USEPA 1992) is a regulatory test used in the classification of hazardous waste under the Resource Conservation and Recovery Act (RCRA). This test is performed at a 20:1 solution to solid ratio. TCLP testing will be performed on any materials that were not previously characterized using TCLP during the RI/FS or by Monsanto; this is anticipated to be limited to the "tailings pond" materials and any previously uncharacterized materials.
- **Synthetic Precipitation Leaching Procedure (SPLP)** – The SPLP leach test (USEPA Method 1312) (USEPA 1994) simulates the short-term interaction between meteoric water and a solid. This test is performed at a 20:1 solution to solid ratio. SPLP testing for this study will be conducted at a 4:1 solution to solid ratio to be more representative of the solution to solid ratio under site conditions.
- **Groundwater Leach Test** – Leach testing will be conducted using site groundwater and site groundwater spiked with magnesium chloride (MgCl). Testing will be conducted at a 4:1 solution to solid ratio for 18-hours (i.e. similar to the SPLP test methodology).

- **Mineralogical Analysis** – In addition to characterization of the forms in which the COCs occur in source materials, mineralogical analysis will be performed on vadose zone samples to confirm the presence, or absence, of secondary mineral phases (i.e. otavite, rhodochrosite and fluorite). Mineralogical analysis methods will be selected based on the type of sample and may include X-ray diffraction (XRD) analysis, microscopy, or scanning electron microprobe (SEM) analysis.

5.2 Groundwater Quality

Groundwater quality samples will be analyzed for the constituents list in Table 4-2. These constituents include the constituents sampled as part of the annual water quality sampling and additional parameters to evaluate geochemical conditions in the former source areas.

6.0 DATA EVALUATION AND REPORT

A report will be prepared describing the field activities and UBZ-2 source area characterization. The report will include the following information:

- Summary of potential sources from information review:
  - Hydrogeologic setting
  - Materials characterization
  - Source area history and closure
  - Groundwater quality
  - Aquifer properties including hydraulic conductivity and groundwater velocity
  - Groundwater flow directions
- Investigation procedures
- Results of field investigations:
  - Borehole, monitoring well, and test pit logs with descriptions of materials intersected and sample locations
  - Infiltration test and rising head test interpretation
  - Results of geochemical characterizations
  - Results of groundwater quality sampling
  - Groundwater elevation hydrographs from the monitoring wells
- Interpretation of results:
  - Geologic and hydrogeologic conditions
  - Source area geochemistry and mineralogy
  - Source area groundwater quality
  - UBZ-2 sources and release mechanisms
  - Conceptual hydrogeologic and geochemical model for UBZ-2 source areas and groundwater pathways within UBZ-2 and UBZ-1

7.0 QUALITY ASSURANCE AND QUALITY CONTROL

7.1 Laboratory Analyses

The primary laboratory used for the groundwater quality, geochemical, and leach analyses is SVL Analytical. The laboratory used for analysis of split samples is Analytical Resources Inc. Other laboratories may be used for specialized analytical services such as mineralogical analyses at the discretion of Monsanto or the Golder project manager.

Contact information for the primary laboratory is:

SVL Analytical
One Government Gulch
PO Box 929
Kellogg, ID 83837-0929
ATTENTION: Chris Meyer
(800) 597-7144 or (208) 784-1258
(208) 783-0891 (fax)

The primary split laboratory is:

Analytical Resources Inc.
4611 South 134th Place
Tukwila, WA 98168
ATTENTION: Mark Harris
(206) 695-6200
(206) 695-6201 (Fax)

The proposed laboratory for XRD analysis is:

SGS Minerals Services, Vancouver
Kent Corporate Centre
#50-655 West Kent Avenue N.
Vancouver, British Columbia, V6P 6T7
(604) 324-1166
(604) 324-1177 (fax)

All analytical samples shall be subject to quality control (QC) measures in both the field and laboratory as detailed in the project QAPPs for groundwater (Appendix C) and solids (Appendix D). The following minimum field quality control requirements apply to all analyses. These requirements are adapted from Test Methods for Evaluating Solid Waste (SW-846), USEPA (2007).

- ***Field duplicate samples***. An effort will be made to obtain sufficient sample quantities for the purpose of collecting field duplicates. Field duplicates will be collected from cuttings or test pit samples that are suspected, based upon field observations, to contain contaminants, and where volume requirements are sufficient. Duplicate samples shall be collected from the same sampling interval using the same equipment and sampling technique, and shall be placed into identically prepared and preserved containers. At a minimum, duplicate samples will be generated for cuttings samples at a frequency of one duplicate per 20 samples. All field duplicates shall be identified with a unique sample ID number and will be analyzed independently (blind) as an indication of gross errors in sampling techniques.

- ***Split laboratory samples***. Split samples are identical samples collected from the same interval at the same time in the same way, contained and transported in the same manner, but are sent to an alternate laboratory. Split samples are used as a performance audit of the primary laboratory. At a minimum, split samples will be generated for cuttings samples frequency of one duplicate per 20 samples. Split sampling shall be distributed evenly throughout each sampling period, with representative samples suspected to contain contaminants and where volume requirements are sufficient.
- ***Equipment blanks.*** Equipment blanks shall consist of pure deionized/ distilled commercially available water washed through decontaminated non-dedicated sampling equipment and placed in containers identical to those used for actual field samples. Equipment blanks verify the adequacy of sample containers, non-dedicated sampling equipment decontamination procedures, and the proficiency of the field technician to eliminate fugitive contaminants. Therefore, equipment blanks will be generated for water collected from monitoring wells and test pit sampling equipment. The equipment blanks shall be collected at a location based upon the potential for the presence of field contaminants.

7.2 Sample Designation

All soil, material, and groundwater samples will be designated with a unique sample identification number in accordance with technical procedure TP-1.2-18 *Technical Procedure for Sampling Surface Soil for Chemical Analysis* (Golder 1996a) and Golder Technical Guideline TG-1.2-20 *Collection of Groundwater Quality Samples* (Golder 2009c).

At a minimum, the sample label shall include the following:

- Unique sample designation
- Sample date and time
- Sampler’s name
- Sample analyte(s)
- Chemical preservative, if required

7.3 Chain of Custody

All samples obtained during the course of this investigation shall be assigned a unique sample number and controlled under Chain of Custody at all times in accordance with technical guideline TG-1.2-23 *Technical Guideline for Chain of Custody* (Golder 2009a). Chain of Custody forms (see Exhibit C in TG-1.2-23) shall be completed for each shipment of samples as described in the procedure. Sample Integrity Data Sheets shall be completed for all sample collection locations, and cross reference the location and sample depth with the sample identification entered on the Chain of Custody. All laboratory chain of custody and sample tracking procedures shall ensure traceability of analytical results to the original samples through the analytical method referenced on the chain of custody, and the laboratory applied tracking number, which is traceable to unique sample identification numbers.

Custody seals will be placed on the refrigerator in the Monsanto lab basement used to store samples until they are shipped to the analytical laboratories.

7.4 Data Validation and Management

Analytical data collected will be validated in accordance with the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Data Review (USEPA 2010) and the Monsanto QAPP (Appendix C).

Validated laboratory data will be uploaded to a database. All hard copy laboratory data and field notes will be archived.

8.0 CLOSING

We hope this report meets with your satisfaction, should you have any questions please call the undersigned.

Regards,

GOLDER ASSOCIATES INC.

DRAFT

Michael Klisch
Senior Project Hydrogeologist

DRAFT

David Banton
Principal Hydrogeologist

MK/DB/sb

9.0 REFERENCES

CH2M Hill. 2010. CH2M HILL Draft Comments on "2009 Summary Report on Groundwater Conditions at the Monsanto Soda Springs Plant", "Technical Memorandum: Evaluation of Natural Attenuation Controls - Monsanto Soda Springs Site" and conclusions on Monitored Natural Attenuation as a Remedy for the Soda Springs Site, June 2010.

Golder Associates Ltd. (Golder). 1985. *Report to Monsanto Industrial Chemical Company on Hydrogeological Investigation, Soda Springs Plant Site, Soda Springs, Idaho, Volumes 1-3*, prepared for Monsanto Chemical Company by Golder Associates, Ltd., Burnaby, B.C. Canada.

Golder. 1986. Technical Procedure TP-1.2-17 Rising Head Slug Test.

Golder. 1992. *Phase I Remedial Investigation/Feasibility Study, Preliminary Site Characterization Summary Report for the Soda Springs Elemental Phosphorus Plant*, prepared for Monsanto Chemical Company by Golder Associates, Inc., Redmond, Washington, April 23.

Golder. 1995. *Phase II Remedial Investigation for the Monsanto Soda Springs Elemental Phosphorus Plant*. Prepared for Monsanto Chemical Company by Golder Associates, Inc., Redmond, Washington. November 21.

Golder. 1996a. Technical Procedure TP 1.2-18, Sampling Surface Soil for Chemical Analysis.

Golder. 1996b. Technical Procedure TP 1.2-3, Drillhole Logging for Rotary/Cable Tool Drilling.

Golder. 1996c, Technical Procedure TP-1.2-5 “Drilling, Sampling, and Logging of Soils”, Redmond, Washington.

Golder. 2003. *First 5-Year Review of Groundwater Conditions at the Soda Springs Plant, Soda Springs, Idaho,* prepared for Monsanto Chemical Company by Golder Associates, Inc., Redmond, Washington.

Golder. 2007. Technical Guideline TG-1.2-21 Technical Guide for Geotechnical Test Pit Logging.

Golder. 2008. *Second 5-Year Review of Groundwater Conditions at the Soda Springs Plant, Soda Springs, Idaho,* prepared for Monsanto Chemical Company by Golder Associates, Inc., Redmond, Washington.

Golder. 2009a. Technical Guideline TG-1.2-23 “Chain of Custody, Rev. #2”, Redmond, Washington.

Golder. 2009b. Technical Guideline TG-1.2-12 “Monitoring Well Drilling and Installation, Rev. #8”, Redmond, Washington.

Golder. 2009c. Technical Guideline TG-1.2-20 “Collection of Groundwater Quality Samples, Rev. #3”, Redmond, Washington.

Golder. 2011, *2009 Revised Summary Report, Groundwater Conditions at the Monsanto Soda Springs Plant, Soda Springs, Idaho,* prepared for Monsanto Chemical Company by Golder Associates, Inc., Redmond, Washington. January 6.

Golder. 2012. *Groundwater and Surface Water Sampling Work Plan, Monsanto Soda Springs Idaho Plant.* June 4.

Golder. 2013 Source Area Characterization - UBZ-2, Phase 1, Monsanto Soda Springs Plant.

Idaho Administrative Code (IAC). 2010. Well Construction Standards Rules (IDAPA 37.03.09), Department of Water Resources, Idaho.

United States Bureau of Reclamation. (USBR). 1990. Earth Manual Part 2, A Water Resources Technical Publication, Third Edition. Procedure 7310 – Constant Head Hydraulic Conductivity Tests in Single Drill Holes.

United States Environmental Protection Agency (USEPA). 1992. Method 1311 – Toxicity Characteristic Leaching Procedure (Revision 0). July.

USEPA. 1994. Method 1312 – Synthetic Precipitation Leaching Procedure (Revision 0). September.

USEPA. 1996. Method 3050b – Acid Digestion of Sediments, Sludges, and Soils. December.

USEPA. 2007. SW-846, Test Methods for Evaluating Solid Wastes, Revision 6, February, 2007.

USEPA. 2010. USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Data Review, Final, EPA-540/R-00-006, January.

TABLES

Table 4-1: Proposed Borehole and Test Pit Locations

Location	Exploration Type	Latitude	Longitude	Northing	Description
Old UFS Ponds - UBZ-2	Borehole and Monitoring Well	TW-71	42.689691°	-111.593228°	Northern Old UFS Pond - Source Area Characterization and Groundwater Quality
	Borehole and Monitoring Well	TW-72	42.687917°	-111.592817°	Southern Old UFS Pond - Source Area Characterization and Groundwater Quality
	Borehole and Monitoring Well	TW-73	42.686775°	-111.592899°	UBZ-2 Groundwater Quality Downgradient of Old UFS Ponds. Location may be adjusted based on proximity to overhead power.
Unidentified Disposal Area - UBZ-2	Borehole and Monitoring Well	TW-74	42.692189°	-111.592822°	UBZ-2 Unidentified Disposal Area - Source Area Characterization and Groundwater Quality
	Test Pit	TP-1	42.684409°	-111.593596°	"Tailings Pond" Source Area Characterization
	Test Pit	TP-2	42.683971°	-111.593700°	"Tailings Pond" Source Area Characterization
	Test Pit	TP-3	42.684935°	-111.593668°	"Tailings Pond" Source Area Characterization
	Test Pit	TP-4	42.685565°	-111.593673°	"Tailings Pond" Source Area Characterization
	Test Pit	TP-5	42.685872°	-111.593309°	"Tailings Pond" Source Area Characterization
	Test Pit	TP-6	42.686196°	-111.593679°	"Tailings Pond" Source Area Characterization
	Test Pit	TP-7	42.686499°	-111.593179°	"Tailings Pond" Source Area Characterization
	Borehole and Monitoring Well	TW-75	42.684636°	-111.592663°	"Tailings Pond" Source Area Characterization and Groundwater Quality
	Borehole and Monitoring Well	TW-76	42.685604°	-111.593399°	"Tailings Pond" Source Area Characterization and Groundwater Quality
Old UFS Ponds - UBZ-4	Borehole and Monitoring Well	TW-77	42.688891°	-111.591720°	Southern Old UFS Pond - Source Area Characterization and Groundwater Quality
	Borehole and Monitoring Well	TW-78	42.687448°	-111.591139°	UBZ-4 Groundwater Quality Downgradient of Old UFS Ponds - Northwest of TW-26. Location may be adjusted based on proximity to overhead power.
	Borehole and Monitoring Well	TW-79	42.685595°	-111.590263°	UBZ-4 Groundwater Quality Downgradient of Old UFS Ponds - South of TW-26. Location may be adjusted based on proximity to overhead power.

Note:
Locations are approximate and will be confirmed following field confirmation of access
Pressure transducers and dataloggers will be installed in all monitoring wells following installation.

Table 4-2: Groundwater Analytical Constituents, Preservatives, Holding Times, and Analytical Methods

Analytical Constituents	Preservative	Filtration	Holding Time	Analytical Methods
Total Metals - All Sampling Locations				
Cadmium	Cool, 4°C: HNO_3 to pH<2	No	6 months	6010C
Calcium	Cool, 4°C: HNO_3 to pH<2	No	6 months	6010C
Magnesium	Cool, 4°C: HNO_3 to pH<2	No	6 months	6010C
Manganese	Cool, 4°C: HNO_3 to pH<2	No	6 months	6010C
Molybdenum	Cool, 4°C: HNO_3 to pH<2	No	6 months	6010C
Potassium	Cool, 4°C: HNO_3 to pH<2	No	6 months	6010C
Selenium	Cool, 4°C: HNO_3 to pH<2	No	6 months	ICAP with hydride generation[a]
Sodium	Cool, 4°C: HNO_3 to pH<2	No	6 months	6010C
Vanadium	Cool, 4°C: HNO_3 to pH<2	No	6 months	6010C
Zinc	Cool, 4°C: HNO_3 to pH<2	No	6 months	6010C
Other Ions - All Sampling Locations				
Total Alkalinity (as $CaCO_3$)	Cool, 4°C	No	14 days	2320B
Bicarbonate Alkalinity (as $CaCO_3$)	Cool, 4°C	No	14 days	2320B
Carbonate Alkalinity (as $CaCO_3$)	Cool, 4°C	No	14 days	2320B
Ammonia and Ammonium as N	Cool, 4°C; H_2SO_4 to pH<2	No	28 days	350.1
Chloride	Cool, 4°C	No	28 days	300
Fluoride	Cool, 4°C	No	28 days	300
Nitrate and Nitrite As N	Cool, 4°C; H_2SO_4 to pH<2	No	28 days	353.2
Total Phosphorus	Cool, 4°C; H_2SO_4 to pH<2	No	28 days	365.2
Sulfate	Cool, 4°C	No	28 days	300
TDS	Cool, 4°C	No	7 days	SM 2540 C
Hardness	Cool, 4°C: HNO_3 to pH<2	No	6 months	2340B
Field Parameters - All Sampling Locations				
Conductivity	None required	Not Applicable	None required	Field Meter
Dissolved Oxygen	None required	Not Applicable	None required	Field Meter
pH	None required	Not Applicable	None required	Field Meter
Turbidity	None required	Not Applicable	None required	Field Meter
Temperature	None required	Not Applicable	None required	Field Meter
Redox Potential	None required	Not Applicable	None required	Field Meter

Note:
a. 6010C and SM 3114C

Table 5-1: Proposed Exploration Materials Characterization

Exploration Type	Material Sampled	Number of Samples per Exploration[a]	Total Number of Analyses				Quality Assurance/Control Samples			Total Number of Samples Including QA/QC
			Elemental Analysis	Leach Testing[b]	Mineralogical Charaterization[b]	Water Quality Analysis	Duplicates	Splits	Equipment/ Field Blanks	
Test Pits (7 test pits)	Soil/Fill materials	1	7	na	na	na	1	1	1	10
	Source materials	2	14	14	14	na	1	1	2	46
	Native materials below sources	2	14	14	14	na	1	1	2	46
Source Area Boreholes (4 boreholes)	Soil/Fill materials	1	4	na	na	na	1	1	1	7
	Cap materials	2	8	na	8	na	1	1	1	19
	Source materials	4	8	8	8	na	1	1	1	27
	Native materials below sources	3	8	8	8	na	1	1	1	27
Monitoring Wells (9)	Groundwater	1	na	na	na	9	1	1	1	12

Note:

a. Actual number of samples per exploration dependent on materials intersected at each location.

b. Samples for leach testing and mineralogial analysis to be selected based on elemental analysis results, types and thickness of materials intersected, and previous characterization data,and concurrence from EPA and IDEQ.

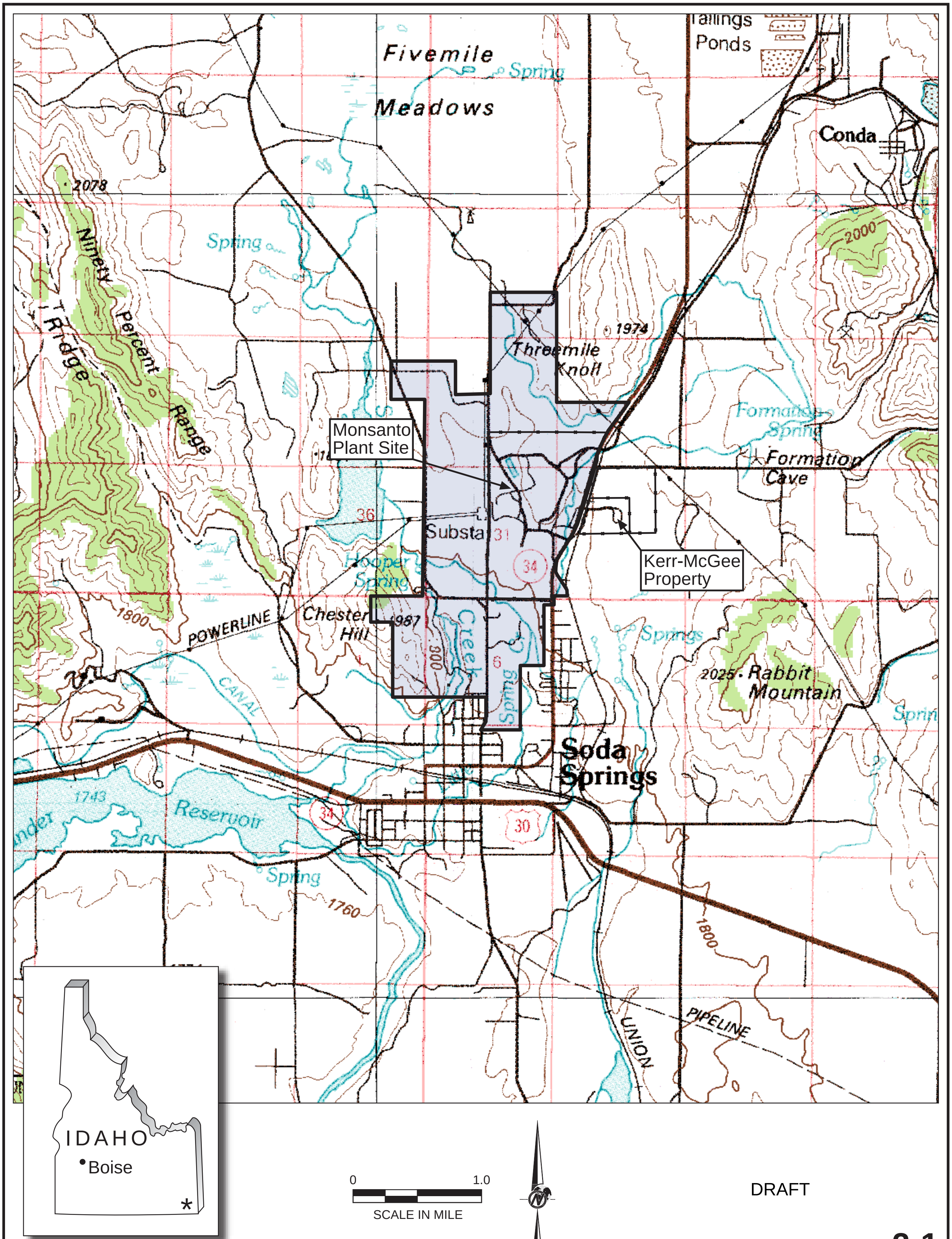
na: Not analyzed

Table 5-2: Proposed Analytical Parameters for Remnant Source and Vadose Zone Materials

Test Type	Analytical Parameter	Proposed Test Methods	Reporting Limits (mg/kg or as noted)	Method Detection Limits (mg/kg)
Geochemical Characterization (elemental analysis)	Alumium	6010B	8.0	2.5
	Arsenic	6010B or 6020B	2.5	0.5
	Cadmium	6010B or 6020B	0.2	0.034
	Calcium	6010B	4.0	1.5
	Chromium	6010B or 6020B	0.6	0.065
	Iron	6010B	6.0	1.9
	Lead	6010B or 6020B	0.75	0.25
	Magnesium	6010B	6.0	1.9
	Manganese	6010B or 6020B	0.4	0.16
	Molybdenum	6010B or 6020B	0.8	0.075
	Nickel	6010B or 6020B	1.0	0.31
	Potassium	6010B	50	15
	Selenium	6010B or 6020B	4.0	0.82
	Silicon	6010B or gravimetric	na	na
	Sodium	6010B	50	2.3
	Strontium	6010B	0.5	0.034
	Zinc	6010B or 6020B	1.0	0.16
	Sulfur (total)	LECO	0.01%	0.01%
Leach Testing (TCLP, SPLP and Groundwater Leaching)	pH	EPA 9045D	na	na
	Conductivity	SM 2510B	5 μmhos/cm	na
	Total Dissolved Solids	SM 2540C	10	na
	Chloride	EPA 300.0	1	0.061
	Sulfate	EPA 300.0	1.5	0.066
	Alkalinity	SM 2320B	1	1
	Nitrate	EPA 300.0	0.25	0.015
	Fluoride	EPA 300.0	0.5	0.017
	Alumium	EPA 200.7 or 6010B	0.08	0.023
	Arsenic	EPA 200.7 or 6010B	0.025	0.0068
	Cadmium	EPA 200.7 or 6010B	0.002	0.0007
	Calcium	EPA 200.7 or 6010B	0.04	0.015
	Chromium	EPA 200.7 or 6010B	0.006	0.0007
	Iron	EPA 200.7 or 6010B	0.06	0.019
	Lead	EPA 200.7 or 6010B	0.0075	0.0034
	Magnesium	EPA 200.7 or 6010B	0.06	0.022
	Manganese	EPA 200.7 or 6010B	0.004	0.0014
	Molybdenum	EPA 200.7 or 6010B	0.008	0.0018
	Nickel	EPA 200.7 or 6010B	0.01	0.003
	Potassium	EPA 200.7 or 6010B	0.5	0.14
	Selenium	EPA 200.7 or 6010B	0.04	0.011
	Silicon	EPA 200.7 or 6010B	0.171	0.051
	Sodium	EPA 200.7 or 6010B	0.5	0.11
	Strontium	EPA 200.7 or 6010B	0.005	0.0011
	Zinc	EPA 200.7 or 6010B	0.01	0.003
	Sulfur (total)	na	na	na

Note:
Detection limits and analytical methods supplied by SVL, Kellog, Idaho

FIGURES



Source: *Topographic map of the USGS Soda Springs Quadrangle (1:100,000) 1982.*

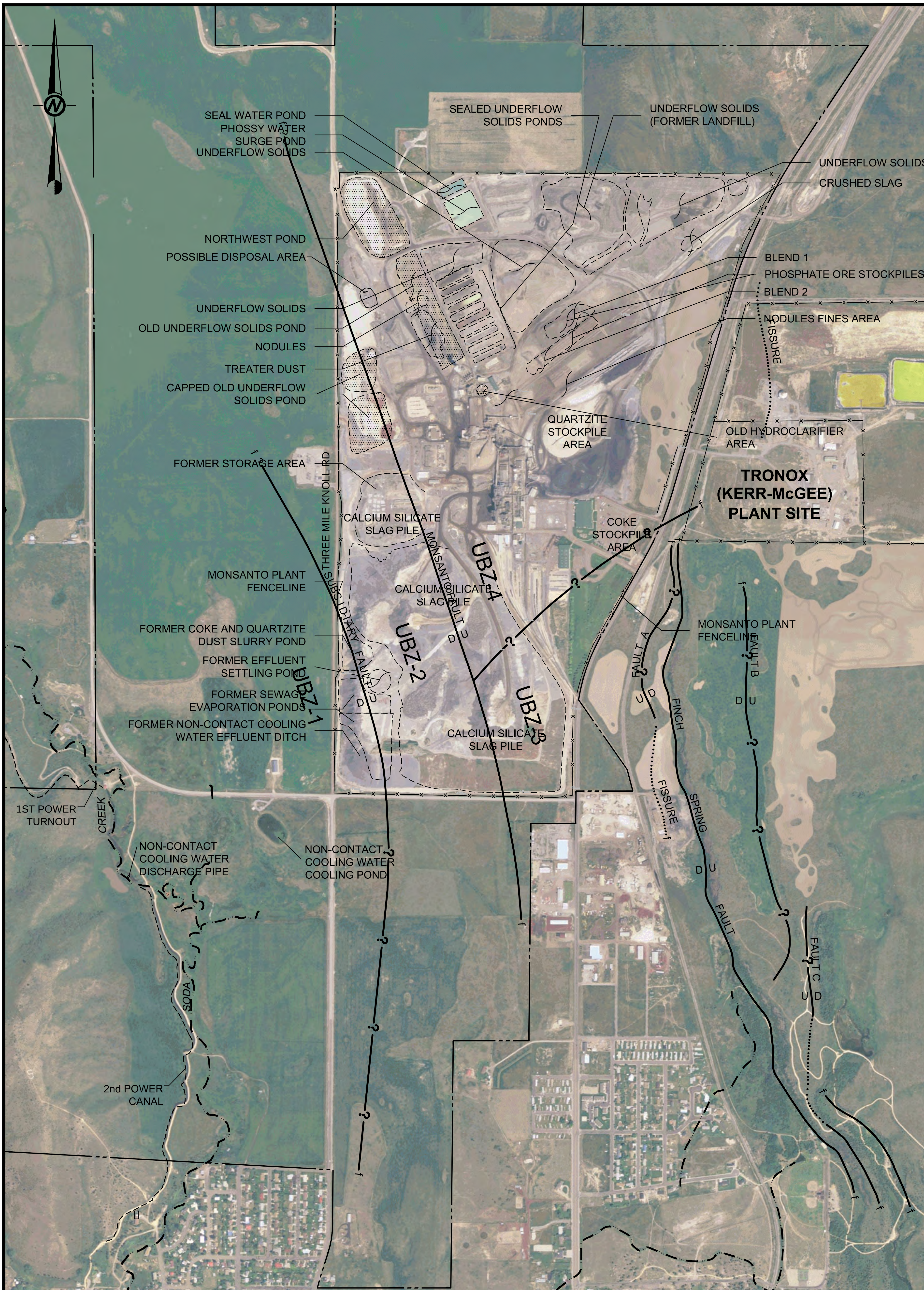
FIGURE **2-1**

MONSANTO PLANT VICINITY MAP

MONSANTO/UBZ-2 SOURCE AREA WORK PLAN/ID

9131101001605afig2-1.ai | Mod: 07/24/13 | AMP

Golder Associates



LEGEND:

f —U/D— f	FAULT	—·—	MONSANTO PROPERTY BOUNDARY (APPROXIMATE)	(dashed outline)	FACILITY AREA
f —U ? D— f	FAULT (INFERRED)	—x—x—	PLANT PERIMETER FENCE	(stippled)	ORIGINAL SOURCE AREA
f ······· f	FISSURE				
UBZ-1	GROUNDWATER ZONE	—··—	CREEK / IRRIGATION DITCH		

0 1000 2000
SCALE IN FEET

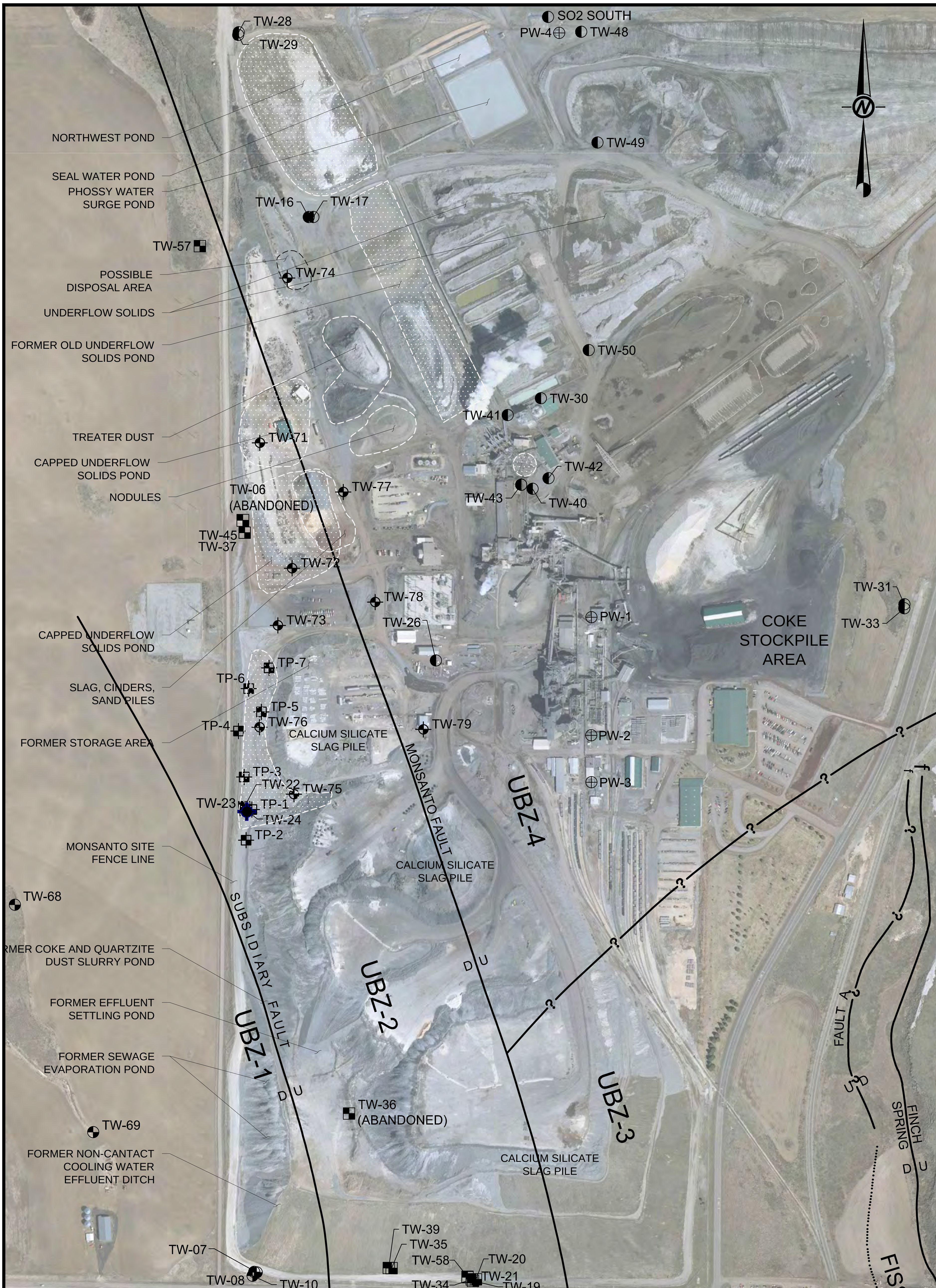
SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).
WELL LOCATIONS BY GOLDER ASSOCIATES, (12/12/2001).

DRAFT

FIGURE **2-2**
MONSANTO FACILITY MAP
Monsanto/Soda Springs 5 yr Review - Phase 2 Source Area Work Plan

K:\CAD\Projects\1991\9131101\x002\002\2G\913-1101_002_002_2G_F2-2.dwg | F2-2 | Mod: 07/23/2013, 09:56 | Plotted: 07/23/2013, 09:56 | JAsprinio

Golder Associates



LEGEND:

f —U/D— f	FAULT	TW-60	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1	TW-71	PROPOSED BOREHOLE LOCATION WITH DESIGNATION
f —U ? D— f	FAULT (INFERRED)	LEWIS	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2	TP-1	PROPOSED TEST PIT LOCATION WITH DESIGNATION
f ······ f	FISSURE	TW-33	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4		
UBZ-1	GROUNDWATER ZONE				

0 500 1000

SCALE IN FEET

DRAFT

FIGURE **4-1**

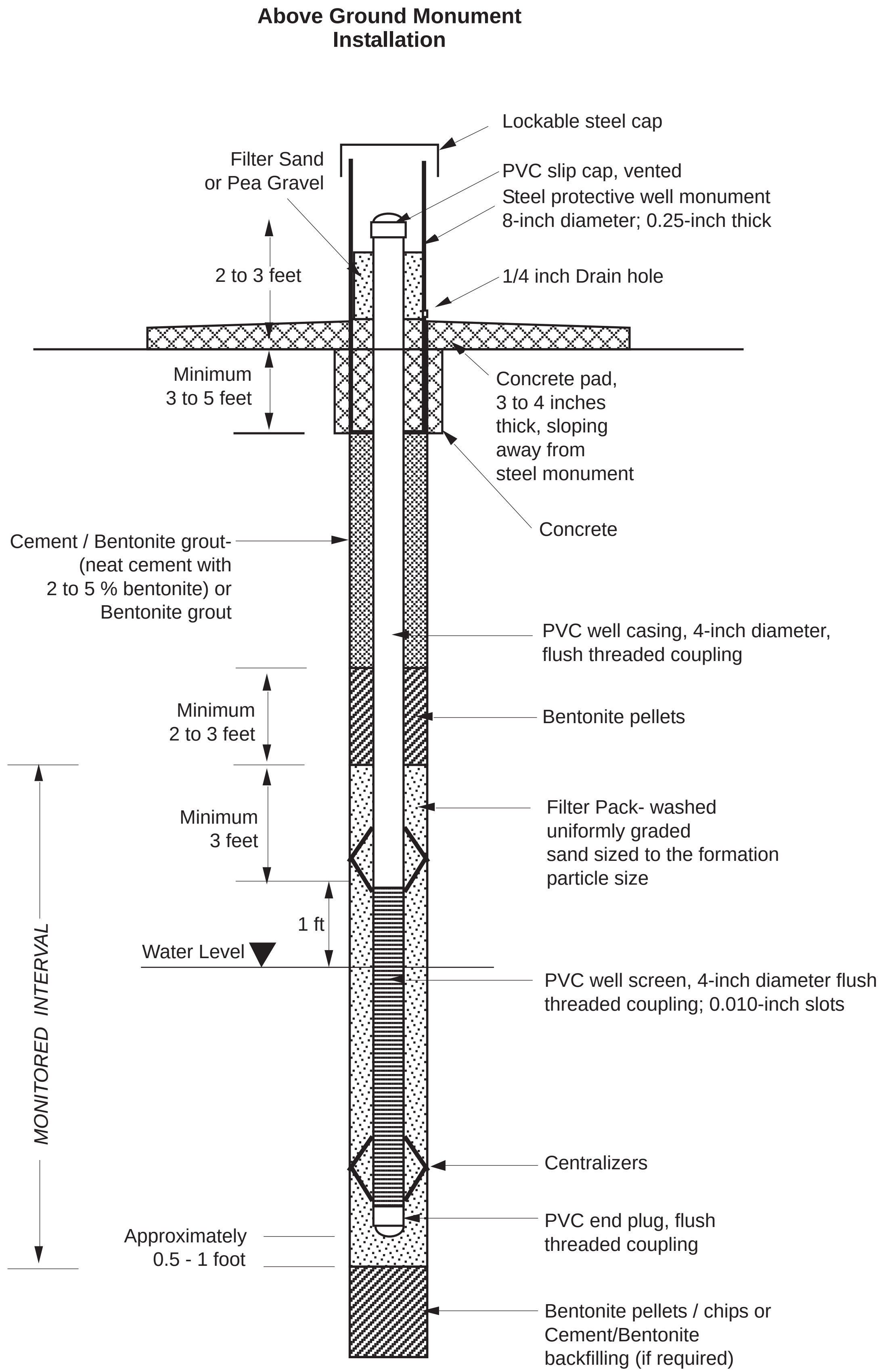
SOURCE:
AERIAL PHOTO FROM MONSANTO (5/18/2011).

PROPOSED BOREHOLE AND TEST PIT LOCATIONS

Monsanto/Soda Springs 5 yr Review - Phase 2 Source Area Work Plan

K:\CAD\Projects\1991\9131101\x002\002\2G\913-1101_002_002_2G_F4-1.dwg | F4-1 | Mod: 07/23/2013, 09:49 | Plotted: 07/23/2013, 09:50 | JAsprinio

Golder Associates



DRAFT

NOT TO SCALE

FIGURE **4-2**

TYPICAL MONITORING WELL INSTALLATION

MONSANTO PHASE 2 SOURCE AREA WORK PLAN

APPENDIX A
STATE OF IDAHO MONITORING WELL CONSTRUCTION REGULATIONS (IDAPA 37.03.09)

Table of Contents

37.03.09 - Well Construction Standards Rules

IDAPA 37
TITLE 03
CHAPTER 09

37.03.09 - WELL CONSTRUCTION STANDARDS RULES

000. LEGAL AUTHORITY (RULE 0).
The Idaho Water Resource Board adopts these administrative rules with the authority provided by Section 42-238(12), Idaho Code. (5-8-09)

001. TITLE AND SCOPE (RULE 1).

01. Title. These rules are cited as IDAPA 37.03.09, "Well Construction Standards Rules." (5-8-09)

02. Scope. The Department of Water Resources has statutory responsibility for the statewide administration of the rules governing well construction. These rules establish minimum standards for the construction of all new wells and the modification and decommissioning (abandonment) of existing wells. The intent of the rules is to protect the ground water resources of the state against waste and contamination. These rules are applicable to all water wells, monitoring wells, low temperature geothermal wells, injection wells, cathodic protection wells, closed loop heat exchange wells, and other artificial openings and excavations in the ground that are more than eighteen (18) feet in vertical depth below land surface as described in these rules pursuant to Section 42-230 Idaho Code. Some artificial openings and excavations do not constitute a well. For the purposes of these rules, artificial openings and excavations not defined as wells are described in Subsection 045.03 of these rules. Any time that such an artificial opening or excavation is constructed, modified, or decommissioned (abandoned) the intent of these rules must be observed. If waste or contamination is attributable to this type of artificial opening or excavation, the artificial opening or excavation must be modified, or decommissioned (abandoned) as determined by the Director. (5-8-09)

002. WRITTEN INTERPRETATION (RULE 2).
In accordance with Section 67-5201(19)(b)(iv), Idaho Code, the Idaho Department of Water Resources may draft and implement written statements that pertain to the interpretation of these rules, or to the documentation of compliance with these rules. (5-8-09)

003. ADMINISTRATIVE APPEALS (RULE 3).
Persons may be entitled to appeal agency actions authorized under these rules pursuant to Section 42-1701A, Idaho Code, and IDAPA 37.01.01, "Rules of Procedure of the Idaho Department of Water Resources" (5-8-09)

004. INCORPORATION BY REFERENCE (RULE 4).
No documents have been incorporated by reference into this chapter. (5-8-09)

005. OFFICE HOURS -- MAILING ADDRESS AND STREET ADDRESS (RULE 5).

01. Office Hours. Office hours are 8 a.m. to 5 p.m. local time, Monday through Friday, except holidays designated by the state of Idaho. (5-8-09)

02. Mailing Address. The mailing address for the state office is: Idaho Department of Water Resources, P.0. Box 83720, Boise, Idaho 83720-0098. (5-8-09)

03. Street Address. The street addresses for the state office of the Department of Water Resources, the regional offices in Idaho Falls, Coeur d'Alene, Twin Falls, and Boise, and the satellite offices in Salmon, and Soda Springs may be obtained by calling the state office at (208) 287-4800, or by visiting the Department's website at http://www.idwr.idaho.gov. (5-8-09)

006. PUBLIC RECORDS ACT COMPLIANCE (RULE 6).
Records maintained by the Department of Water Resources are subject to the provisions of the Idaho Public Records Act, Title 9, Chapter 3, Sections 9-337 through 9-349, Idaho Code. (5-8-09)

007. -- 009. (RESERVED)

010. DEFINITIONS (RULE 10).

Unless the context otherwise requires, the following definitions apply to these rules. (5-8-09)

01. Approved Seal or Seal Material. Seal material must consist of bentonite chips, pellets, or granules, bentonite grout, neat cement, or neat cement grout as defined by these rules. No other materials may be used unless specifically authorized by the Director (5-8-09)

02. Annular Space. The space, measured as one-half (1/2) the difference in diameter between two (2) concentric cylindrical objects, one of which surrounds the other, such as the space between the walls of a drilled hole (borehole) and a casing or the space between two (2) strings of casing. (5-8-09)

03. Aquifer. Any geologic formation(s) that will yield water to a well in sufficient quantities to make the production of water from the formation feasible for beneficial use. (5-8-09)

04. Area of Drilling Concern. An area designated by the Director in which drillers must comply with additional standards to prevent waste or contamination of ground or surface water due to such factors as aquifer pressure, vertical depth of the aquifer, warm or hot ground water, or contaminated ground or surface waters, in accordance with Section 42-238(7), Idaho Code. (5-8-09)

05. Artesian Water. Any water that is confined in an aquifer under pressure so that the water will rise in the well casing or drilled hole above the elevation where it was first encountered. This term includes water of flowing and non-flowing wells. (5-8-09)

06. Artificial Filter Pack. Clean, rounded, smooth, uniform, sand or gravel placed in the annular space around a perforated well casing or well screen. A filter pack is frequently used to prevent the movement of finer material into the well casing and to increase well efficiency. (5-8-09)

07. Bentonite. A commercially processed and packaged, low permeability, sodium montmorillonite clay certified by the NSF International for use in well construction, sealing, plugging, and decommissioning (abandonment). All bentonite products used in the construction or decommissioning (abandoning) of wells must have a permeability rating not greater than 10^{-7} (ten to the minus seven) cm/sec. (5-8-09)

a. Chips. Bentonite composed of pieces ranging in size from one-quarter (1/4)-inch to one (1) inch on their greatest dimension. (5-8-09)

b. Granules (also Granular). Bentonite composed of pieces ranging in size from one thirty-seconds (1/32) inch (#20 standard mesh) to seven thirty-seconds (7/32) inch (#3 standard mesh) on their greatest dimension. (5-8-09)

c. Bentonite Grout. A mixture of bentonite specifically manufactured for use as a well sealing or plugging material and potable water to produce a grout with an active solids content not less than twenty-five percent (25%) by weight e.g., (twenty-five percent (25%) solids content by weight = fifty (50) pounds bentonite per eighteen (18) gallons of water). (5-8-09)

d. Pellets. Bentonite manufactured for a specific purpose and composed of uniform sized, one-quarter (1/4) inch, three-eighths (3/8) inch, or one-half (1/2) inch pieces on their greatest dimension. (5-8-09)

08. Board. The Idaho Water Resource Board. (7-1-93)

09. Bore Diameter. The diameter of the hole in the formation made by the drill bit or reamer. (7-1-93)

10. Borehole (also Well Bore). The subsurface hole created during the drilling process. (5-8-09)

11. Bottom Hole Temperature of an Existing or Proposed Well. The temperature of the ground water encountered in the bottom of a well or borehole. (5-8-09)

12. Casing. The permanent conduit installed in a well to provide physical stabilization, prevent caving or collapse of the borehole, maintain the well opening and serve as a solid inner barrier to allow for the installation of an annular seal. Casing does not include temporary surface casing, well screens, liners, or perforated casing as otherwise defined by these rules. (5-8-09)

13. Cathodic Protection Well. Any artificial excavation in excess of eighteen (18) feet in vertical depth constructed for the purpose of protecting certain metallic equipment in contact with the ground. Commonly referred to as cathodic protection. (7-1-93)

14. Closed Loop Heat Exchange Well. A ground source thermal exchange well constructed for the purpose of installing any underground system through which fluids are circulated but remain isolated from direct contact with the subsurface or ground water. (5-8-09)

15. Conductor Pipe. The first and largest diameter string of permanent casing to be installed in a low temperature geothermal resource well. (5-8-09)

16. Confining Layer. A subsurface zone of low-permeability earth material that naturally acts to restrict or retard the movement of water or contaminants from one zone to another. The term does not include topsoil. (5-8-09)

17. Consolidated Formations. Naturally-occurring geologic formations that have been lithified (turned to stone) such as sandstone and limestone, or igneous rocks such as basalt and rhyolite, and metamorphic rocks such as gneiss and slate. (5-8-09)

18. Contaminant. Any physical, chemical, ion, radionuclide, synthetic organic compound, microorganism, waste, or other substance that does not occur naturally in ground water or that naturally occurs at a lower concentration. (5-8-09)

19. Contamination. The introduction into the natural ground water of any physical, chemical, biological or radioactive material that may: (7-1-93)

a. Cause a violation of Idaho Ground Water Quality Standards; or (5-8-09)

b. Adversely affect the health of the public; or (7-1-93)

c. Adversely affect a designated or beneficial use of the State's ground water. Contamination includes the introduction of heated or cooled water into the subsurface that will alter the ground water temperature and render the local ground water less suitable for beneficial use, or the introduction of any contaminant that may cause a violation of IDAPA 58.01.11, "Ground Water Quality Rule." (5-8-09)

20. Decommissioned (Abandoned) Well. Any well that has been permanently removed from service and filled or plugged in accordance with these rules so as to meet the intent of these rules. A properly decommissioned well will not: (5-8-09)

a. Produce or accept fluids; (5-8-09)

b. Serve as a conduit for the movement of contaminants inside or outside the well casing; or (5-8-09)

c. Allow the movement of surface or ground water into unsaturated zones, into another aquifer, or between aquifers. (5-8-09)

21. Decontamination. The process of cleaning equipment intended for use in a well in order to prevent the introduction of contaminants into the subsurface and contamination of natural ground water. (5-8-09)

22. Department. The Idaho Department of Water Resources. (7-1-93)

23. Dewatering Well. A well constructed for the purpose of improving slope stability, drying up borrow pits, or intercepting seepage that would otherwise enter an excavation. (5-8-09)

24. Director. The Director of the Idaho Department of Water Resources or his duly authorized representatives. (7-1-93)

25. Disinfection. The introduction of chlorine or other agent or process approved by the Director in sufficient concentration and for the time required to inactivate or kill fecal and Coliform bacteria, indicator organisms, and other potentially harmful pathogens. (5-8-09)

26. Draw Down. The difference in vertical distance between the static water level and the pumping water level. (5-8-09)

27. Drive Point (also known as a Sand Point). A conduit pipe or casing through which ground water of any temperature is sought or encountered created by joining a "drive point unit" to a length of pipe and driving the assembly into the ground. (5-8-09)

28. Exploratory Well. A well drilled for the purpose of discovering or locating new resources in unproven areas. They are used to extract geological, hydrological, or geophysical information about an area. (5-8-09)

29. Global Positioning System (GPS). A global navigational receiver unit and satellite system used to triangulate a geographic position. (5-8-09)

30. Hydraulic Conductivity. A measurement of permeability. (5-8-09)

31. Hydraulic Fracturing. A process whereby water or other fluid is pumped under high pressure into a well to further fracture the reservoir rock or aquifer surrounding the production zone of a well to increase well yield. (5-8-09)

32. Injection Well. Any excavation or artificial opening into the ground which meets the following three (3) criteria: (7-1-93)

a. It is a bored, drilled or dug hole, or is a driven mine shaft or driven well point; and (7-1-93)

b. It is deeper than its largest straight-line surface dimension; and (7-1-93)

c. It is used for or intended to be used for subsurface placement of fluids. (7-1-93)

33. Intermediate String or Casing. The casing installed and sealed below the surface casing within a low temperature geothermal resource well to isolate undesirable water or zones below the bottom of the surface casing. Such strings may either be lapped into the surface casing or extend to land surface. (5-8-09)

34. Liner. (5-8-09)

a. A conduit pipe that can be removed from the borehole or well that is used to serve as access and protective housing for pumping equipment and provide a pathway for the upward flow of water within the well. (5-8-09)

b. Liner does not include casing required to prevent caving or collapse, or both, of the borehole or serve as a solid inner barrier to allow for the installation of an annular seal. (5-8-09)

35. Mineralized Water. Any naturally-occurring ground water that has an unusually high amount of chemical constituents dissolved within the water. Water with five thousand (5000) mg/L or greater total dissolved solids is considered mineralized. (5-8-09)

36. Modify. To deepen a well, increase or decrease the diameter of the casing or the well bore, install a liner, place a screen, perforate existing casing or liner, alter the seal between the casing and well bore, or alter the well to not meet well construction standards. (5-8-09)

37. Monitoring Well. Any well more than eighteen (18) feet in vertical depth constructed to evaluate, observe or determine the quality, quantity, temperature, pressure or other characteristics of the ground water or aquifer. (7-1-93)

38. Neat Cement. A mixture of water and cement in the ratio of not more than six (6) gallons of water to ninety-four (94) pounds of Portland cement (neat cement). Other cement grout mixes may be used if specifically approved by the Director. (5-8-09)

39. Neat Cement Grout. Up to five percent (5%) bentonite by dry weight may be added per sack of cement (neat cement grout) and the water increased to not more than six and one-half (6.5) gallons per sack of cement. Other neat cement mixes may be used if specifically approved by the Director. These grouts must be mixed and installed in accordance with the American Petroleum Institute Standards - API Class A through H. As found in API RP10B, "Recommended Practice for Testing Oil Well Cements and Cement Additives," current edition or other approved standards. (5-8-09)

40. Oxidized Sediments. Sediments, characterized by distinct coloration, typically shades of brown, red, or tan, caused by the alteration of certain minerals in an environment with a relative abundance of oxygen. (5-8-09)

41. Perforated Well Casing. Well casing that has been modified by the addition of openings created by drilling, torch cutting, saw cutting, mechanical down-hole perforator, or other method. (5-8-09)

42. Pitless Adaptor or Pitless Unit. An assembly of parts designed for attachment to a well casing which allows buried pipe to convey water from the well or pump and allows access to the interior of the well casing for installation or removal of the pump or pump appurtenances, while maintaining a water tight connection through the well casing and preventing contaminants from entering the well. (5-8-09)

43. Potable Water. Water of adequate quality for human consumption. (5-8-09)

44. Pressure Grouting (Grouting). The process of pumping and placing an approved grout mixture into the required annular space, by positive displacement from bottom to top using a tremie pipe, Halliburton method, float shoe, or other method approved by the Director. (5-8-09)

45. Production Casing. The casing or tubing through which a low temperature geothermal resource is produced. This string extends from the producing zone to land surface. (5-8-09)

46. Public Water System. A system for the provision to the public of water for human consumption through pipes or, after August 5, 1998, other constructed conveyances, if such system has at least fifteen (15) service connections, regardless of the number of water sources or configuration of the distribution system, or regularly serves an average of at least twenty-five (25) individuals daily at least sixty (60) days out of the year. Such term includes: (5-8-09)

a. Any collection, treatment, storage, and distribution facilities under the control of the operator of such system and used primarily in connection with such system; and (5-8-09)

b. Any collection or pretreatment storage facilities not under such control that are used primarily in connection with such system. (5-8-09)

c. Such term does not include any "special irrigation district." (5-8-09)

d. A public water system is either a "community water system" or a "non-community water system." (5-8-09)

47. Reduced Sediments. Sediments, characterized by distinct coloration, typically shades of blue, black, gray, or green, caused by the alteration of certain minerals in an oxygen poor environment. (5-8-09)

48. Remediation Well. A well used to inject or withdraw fluids, vapor, or other solutions approved by the Director for the purposes of remediating, enhancing quality, or controlling potential or known contamination. Remediation wells include those used for air sparging, vapor extraction, or injection of chemicals for remediation or in-situ treatment of contaminated sites. (5-8-09)

49. Sand. Any sediment particle retained on a U.S. standard sieve #200 (Seventy-five hundreths (0.075) mm to two (2) mm). (5-8-09)

50. Screen (Well Screen). A commercially produced structural tubular retainer with standard sized openings to facilitate production of sand free water. (5-8-09)

51 Seal or Sealing. The placement of approved seal material in the required annular space between a borehole and casing, between casing strings, or as otherwise required to create a low permeability barrier and prevent movement or exchange of fluids. Seals are required in the construction of new wells, repair of existing wells, and in the decommissioning (abandonment) of wells. Seals are essential to the prevention of waste and contamination of ground water. (5-8-09)

52. Start Card. An expedited drilling permit process for the construction of cold water, single-family residential wells. (5-8-09)

53. Static Water Level. The height at which water will rise in a well under non-pumping conditions. (5-8-09)

54. Surface Casing. The first string of casing in a low temperature geothermal resource well which is set and sealed after the conductor pipe to anchor blow out prevention equipment and to case and seal out all existing cold ground water zones. (5-8-09)

55. Temporary Surface Casing. Steel pipe used to support the borehole within unstable or unconsolidated formations during construction of a well that will be removed following the installation of the permanent well casing and prior to or during placement of an annular seal. (5-8-09)

56. Thermoplastic/PVC Casing. Plastic piping material meeting the requirements of ASTM F 480 and specifically designed for use as well casing. (5-8-09)

57. Transmissivity. The capacity of an aquifer to transmit water through its entire saturated thickness. (5-8-09)

58. Tremie Pipe. A small-diameter pipe used to convey grout, dry bentonite products, or filter pack materials into the annular space, borehole, or well from the bottom to the top of a borehole or well. (5-8-09)

59. Unconfined Aquifer. An aquifer in which the water table is in contact with and influenced by atmospheric pressure through pore spaces in the overlying formation(s). (5-8-09)

60. Unconsolidated Formation. A naturally-occurring earth formation that has not been lithified. Alluvium, soil, sand, gravel, clay, and overburden are some of the terms used to describe this type of formation. (7-1-93)

61. Unstable Unit. Unconsolidated formations, and those portions of consolidated formations, that are not sufficiently hard or durable enough to sustain an open borehole without caving or producing obstructions without the aid of fluid hydraulics or other means of chemical or physical stabilization. (5-8-09)

62. Unusable Well. Any well that can not be used for its intended purpose or other beneficial use authorized by law. (5-8-09)

63. Waiver. Approval in writing by the Director of a written request from the well driller and the well owner proposing specific variance from the minimum well construction standards. (5-8-09)

64. **Waste**. The loss, transfer, or subsurface exchange of a ground water resource, thermal characteristic, or natural artesian pressure from any aquifer caused by improper construction, misuse, or failure to properly maintain a well. Waste includes: (5-8-09)

a. The flow of water from an aquifer into an unsaturated subsurface zone; (5-8-09)

b. The transfer or mixing, or both, of waters from one aquifer to another (aquifer commingling); or (5-8-09)

c. The release of ground water to the land surface whenever such release does not comply with an authorized beneficial use. (5-8-09)

65. **Water Table**. The height at which water will rise in a well; also the upper surface of the zone of saturation in an unconfined aquifer. This level will change over time due to changes in water supply and aquifer impacts. (5-8-09)

66. **Well**. (5-8-09)

a. An artificial excavation or opening in the ground more than eighteen (18) feet in vertical depth below land surface by which ground water of any temperature is sought or obtained. The depth of a well is determined by measuring the maximum vertical distance between the land surface and the deepest portion of the well. Any water encountered in the well is considered to be obtained for the purpose of these rules; or (5-8-09)

b. Any waste disposal and injection well, as defined in Section 42-3902, Idaho Code. (5-8-09)

c. Well does not mean: (5-8-09)

i. A hole drilled for mineral exploration; or (5-8-09)

ii. Holes drilled for oil and gas exploration which are subject to the requirements of Section 47-320, Idaho Code; or (5-8-09)

iii. Holes drilled for the purpose of collecting soil samples above the water table. (5-8-09)

67. **Well Development**. The act of bailing, jetting, pumping, or surging water in a well to remove drilling fluids, fines, and suspended materials from within a completed well and production zone in order to establish the optimal hydraulic connection between the well and the aquifer. (5-8-09)

68. **Well Driller or Driller**. Any person who operates drilling equipment, or who controls or supervises the construction of a well, and is licensed under Section 42-238, Idaho Code (5-8-09)

69. **Well Drilling or Drilling**. The act of constructing a new well or modifying or changing the construction of an existing well. (5-8-09)

70. **Well Owner**. Any person, firm, partnership, co-partnership, corporation, association, or other entity, or any combination of these, who owns the property on which the well is or will be located or has secured ownership of the well by means of a deed, covenant, contract, easement, or other enforceable legal instrument for the purpose of benefiting from the well. (5-8-09)

71. **Well Rig (Drill Rig)**. Any power driven percussion, rotary, boring, digging, jetting or auguring machine used in the construction of a well. (5-8-09)

011. -- 024. (RESERVED)

025. CONSTRUCTION OF COLD WATER WELLS (RULE 25).

All persons constructing wells must comply with the requirements of Section 42-238, Idaho Code, and IDAPA 37.03.10, “Well Driller Licensing Rules.” The standards specified in Rule 25 apply to all wells with a bottom hole temperature of eighty-five (85) degrees Fahrenheit or less. Wells with a bottom hole temperature greater than eighty-five (85) degrees Fahrenheit, but less than two hundred twelve (212) degrees Fahrenheit, must meet the requirements of Rule 30 in addition to meeting the requirements of Rule 25. These standards also apply to any waste disposal and injection well as defined in Section 42-3902, Idaho Code. (5-8-09)

01. General. The well driller must construct each well as follows: (5-8-09)

a. In accordance with these rules and with the conditions of approval of any drilling permit issued pursuant Section 42-235, Idaho Code, and in a manner that will prevent waste and contamination of the ground water resources of the state of Idaho. The adopted standards are minimum standards which must be adhered to in the construction of all new wells, and in the modification or decommissioning (abandonment) of existing wells. The well driller is charged with the responsibility of preventing waste or contamination of the ground water resources during the construction, modification or abandonment of a well. The Director may add conditions of approval to a drilling permit issued pursuant to Rule 45 of these rules to require that a well be constructed, modified, or decommissioned (abandoned) in accordance with additional standards when necessary to protect ground water resources and the public health and safety from existing contamination and waste or contamination during the construction, modification or decommissioning (abandonment) of a well. (5-8-09)

b. In consideration of the geologic and ground water conditions known to exist or anticipated at the well site. (5-8-09)

c. Such that it is capable of producing, where obtainable, the quantity of water to support the allowed or approved beneficial use of the well, subject to law; (5-8-09)

d. Meet the siting and separation distance requirements in the table in this Subsection (025.01.d.). Additional siting and separation distance requirements are set forth by the governing district health department and the Idaho Department of Environmental Quality rules at IDAPA 58.01.03, “Individual/Subsurface Sewage Disposal Rules,” and IDAPA 58.01.08, “Idaho Rules for Public Drinking Water Systems”.

Separation of Well from:		Minimum Separation Distance (feet)
Existing Public Water Supply well, separate ownership	-	50
Other existing well, separate ownership	-	25
Septic drain field	-	100
Septic tank	-	50
Drainfield of system with more than 2,500 GPD of sewage inflow	-	300*
Sewer line - main line or sub-main, pressurized, from multiple sources	-	100
Sewer line - main line or sub-main, gravity, from multiple sources	-	50
Sewer line - secondary, pressure tested, from a single residence or building	-	25
Effluent pipe	-	50
Property line	-	5
Permanent buildings, other than those to house the well or plumbing apparatus, or both	-	10
Above ground chemical storage tanks	-	20
Permanent (more than six months) or intermittent (more than two months) surface water	-	50

Separation of Well from:		Minimum Separation Distance (feet)
Canals, irrigation ditches or laterals, & other temporary (less than two months) surface water	-	25
*This distance may be less if data from a site investigation demonstrates compliance with IDAPA 58.01.03, "Individual/Subsurface Sewage Disposal Rules," separation distances.		

(5-8-09)

02. **Waivers**. In unique cases where the Director concludes that the ground water resources will be protected against waste and contamination and the public health and safety are not compromised, a waiver of specific standards required by these rules may be approved prior to constructing, decommissioning, or modifying a well. (5-8-09)

a. To request a waiver the well driller and well owner must: (5-8-09)

i. Jointly submit a detailed plan and written request identifying a specific Rule or Rules proposed to be waived. Additionally, the plan must detail the well construction process that will be employed in lieu of complete Rule compliance: (5-8-09)

ii. Prior to submittal, the well driller and the well owner must sign the plan and written request acknowledging concurrence with the request; and (5-8-09)

iii. Submit the plan and request by facsimile, e-mail, or letter. (5-8-09)

b. The Director will evaluate and respond to the request within ten (10) business days of receiving the request. (5-8-09)

i. If the request for waiver is approved, the intent of the rules will be served and all standards not waived will apply. Waivers approved by the Director will not supersede requirements of other regulatory agencies without specific concurrence from that agency. Work activity related to a waiver request will not proceed until a written or verbal approval is granted by the Director. (5-8-09)

ii. Any verbal approval will be followed by a written approval. (5-8-09)

03. **Records**. In order to enable a comprehensive survey of the extent and occurrence of the state's ground water resource, the coordinates of every newly constructed, modified or decommissioned (abandoned) well location must be identified by latitude and longitude with a global positioning system (GPS) and recorded on the driller's report in degrees and decimal minutes and within the nearest 40 acre parcel using the Public Land Survey System. Every well driller must maintain records as described in IDAPA 37.03.10 "Well Driller Licensing Rules," pursuant to Section 42-238(11), Idaho Code, and provide the well owner with a copy of the approved well drilling permit and a copy of the well driller's report when submitted to the Director. (5-8-09)

04. **Casing**. The well driller must install casing in every well. Steel or thermoplastic casing may be installed in any well with a bottom hole temperature of eighty-five (85) degrees Fahrenheit or less. Thermoplastic pipe must not be installed in a well with a bottom hole temperature greater than eighty-five (85) degrees Fahrenheit. All casing to be installed must be new or in like-new condition, free of defects, and clearly marked by the manufacturer with all specifications required by these rules. For all wells the casing must extend at least twelve (12) inches above land surface and finished grade and to a minimum depth below land surface as required by these rules. Concrete slabs around a well casing will be considered finished grade (Figure 01, Appendix A).The well driller must install casing of sufficient strength to withstand calculated and anticipated subsurface forces and corrosive effects. The well driller must install casings sufficiently plumb and straight to allow the installation or removal of screens, liners, pumps and pump columns without causing adverse effects on the operation of the installed pumping equipment. (5-8-09)

a. Steel Casing. When steel casing lengths are joined together, they must be joined by welded joints or screw-couple joints. All connection must be water tight. If steel casing joints are welded, the weld must be at least as thick as the well casing and fully penetrating. Welding rods or flux core wire of at least equal quality to the casing metal must be used. Casing ends to be joined by welding must be properly prepared, beveled and gapped to allow full penetration of the weld. All stick welded joints must have a minimum of two (2) passes including a "root" pass and have minimal undercut when complete. (5-8-09)

i. In addition to meeting these standards, all wells that are constructed for public water systems must meet all of the casing wall thickness requirements set forth by the Idaho Department of Environmental Quality Rules, IDAPA 58.01.08, "Idaho Rules for Public Drinking Water Systems." (5-8-09)

ii. The well driller must install steel casing that meets or exceeds the American Society of Testing and Materials (ASTM) standard A53, Grade B or American Petroleum Institute (API) 5L Grade B, and that meets the following specifications for wall thickness:

Minimum Single-Wall Steel Well Casing Thickness1 for Selected Diameters (inches)													
Nominal Diameter (in.)[3]	**6[2]**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**
Depth (ft.)	Nominal Wall Thickness (in.)[1]												
<100	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
100-200	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
200-300	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
300-400	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.375	0.375	0.375	0.375
400-600	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.375	0.375	0.375	0.375	0.375
600-800	0.250	0.250	0.250	0.250	0.250	0.250	0.375	0.375	0.375	0.375	0.375	0.375	0.375
800-1000	0.250	0.250	0.250	0.250	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375
1000-1500	0.280	0.322	0.365	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375
1500-2000	0.280	0.322	0.365	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375

1 Compliance with the minimum nominal wall thicknesses listed is required for any depth or location where casing is used to prevent caving or collapse, or both, of the borehole or serves as a solid inner barrier to allow for the installation of an annular seal.
2 For nominal casing diameters less than six (6) inches, the minimum nominal wall thickness must be equivalent to ASTM Schedule 40.
3 For any other casing diameter not addressed herein, prior approval by the Director is required.

b. Thermoplastic Casing. Thermoplastic casing may be used in monitoring wells and cold water wells if drilling of the borehole confirms its suitability for use. (5-8-09)

i. Thermoplastic casing must conform to ASTM F 480 and NSF-WC. The well driller must not use thermoplastic casing under any condition where the manufacturer's resistance to hydraulic collapse pressure (RHCP) or total depth specifications are exceeded. Thermoplastic casing extending above-ground must be protected from physical and ultraviolet light damage by enclosing it within steel casing extending at least twelve (12) inches above land surface and finished grade and to a minimum depth of eighteen (18) feet below land surface or five (5) feet below land surface for monitoring wells. (5-8-09)

ii. Thermoplastic pipe used in wells as casing or liner must have a minimum rating of SDR-21. For nominal diameters of four (4) inches or less, a minimum rating of Schedule 40 is required. If used as casing within unconsolidated or unstable consolidated formations, thermoplastic pipe must be centralized and fully supported throughout the unstable zone(s) with filter pack or seal material as required by these rules. (5-8-09)

iii. All thermoplastic casing and liner must be installed in accordance with the manufacturer's recommendations and specifications, and as required by these rules. The well driller will not treat thermoplastic pipe in any manner that would adversely affect its structural integrity. The well driller must: (5-8-09)

(1) Ensure that the weight of the pump assembly, if secured to the thermoplastic pipe, does not exceed the weight limitations per manufacturer's recommendations or cause damage to the pipe resulting in breaks or leaks. (5-8-09)

(2) Not use Type III (high-early strength) Portland cement-based seal materials in direct contact with thermoplastic pipe unless approved by the Director. (5-8-09)

(3) Not drive, drop, force, or jack thermoplastic pipe into place. Thermoplastic pipe must be lowered or floated into an oversized, obstruction-free borehole. (5-8-09)

c. Perforated Well Casing. Perforated well casing may be used in the construction or decommissioning of a well when such application does not violate any standards required by these rules. (5-8-09)

05 **Liner**. In addition to well casing, liners may be installed in wells to prevent damage to pumping equipment. Steel or thermoplastic pipe may be installed as liner in a well with a bottom hole temperature of eighty-five (85) degrees Fahrenheit or less. Thermoplastic liner must conform to ASTM F 480 and NSF-WC. Thermoplastic liners must not be used in unconsolidated formations or unstable units. (5-8-09)

06. **Screen**. Well screens must be used in constructing a well when necessary to avoid sand production (see sand production, Rule 25, Subsection 025.24). Well screens must be commercially manufactured, be slotted, louvered or wire wrapped, and be installed according the manufacturers specifications. (5-8-09)

a. Screens may require a filter pack consisting of sand or gravel to further reduce the quantity of sand produced from the well. (5-8-09)

b. The well driller will not install well screens, perforated casing or filter pack across a confining layer(s) separating aquifers of different pressure, temperature, or quality. (5-8-09)

07. **Use of Approved Sealing Materials and Required Annular Space**. Well casings must be sealed in the required annular space with approved material to prevent the possible downward movement of contaminated surface waters or other fluids in any annular space around the well casing (Figure 02, Appendix A). Proper sealing is also required to prevent the movement of groundwater either upward or downward from zones of different pressure, temperature or quality within the well or outside the casing. The well driller must notify by phone the Department's appropriate Region Office at least four (4) hours in advance of placing any annular seal to provide Department staff the opportunity to observe seal placement. (5-8-09)

a. All casing to be sealed must be adequately centralized to ensure uniform seal thickness around the well casing. Surface seals must extend to not less than thirty-eight (38) feet below land surface for well depths greater than thirty-eight (38) feet. For well depths less than thirty-eight (38) feet, seals must extend to depths as hereafter required. (5-8-09)

b. Seals are required at depths greater than thirty-eight (38) feet in artesian wells or to seal through confining layers separating aquifers of differing pressure, temperature, or quality in any well. (5-8-09)

c. When a well is modified and the existing casing is moved or the original seal is damaged, or a well driller discovers that a seal was not installed or has been damaged, the well driller must repair, replace, or install a seal around the permanent casing that is equal to or better than required when the well was originally constructed. (5-8-09)

d. Manufactured packers and shale traps may be used as devices to retain approved seal material when installing a required annular seal. Whenever these devices are used to retain seal material, the well driller must comply with the manufacturer's recommendations for installation. (5-8-09)

e. If a temporary casing has been installed, upon completion of the drilling, the annular space must be filled with approved seal material and kept full while withdrawing the temporary casing. Bentonite chips should be used with caution when the annular space between a temporary casing and permanent casing is filled with water. (5-8-09)

i. When attempts at removing a temporary casing are unsuccessful, the casing must be sealed in place by a method approved by the department. (5-8-09)

ii. The well driller must notify the department whenever a temporary casing can not be removed and propose a plan to adequately seal the casing to prevent waste and contamination of the ground water. The plan must detail how the casing will be sealed on the outside to a sufficient depth below land surface in addition to placement of any required formation seals through the interval at which the casing will remain. (5-8-09)

f. For mixed grout seals the minimum annular space required must provide for a uniform seal thickness not less than one (1) inch on all sides of the casing or a borehole at least two (2) inches larger than the outside diameter (OD) of the casing to be sealed (Figure 02, Appendix A). (Note: a seven and seven-eighths (7 7/8) inch diameter (eight (8) inch nominal) borehole around a six and five-eighths (6 5/8) inch OD (six (6) inch nominal casing does not satisfy the minimum annular space requirements). (5-8-09)

i. When placing grout seals with a removable tremie pipe between casing strings or between a borehole and casing, the required annular space must be at least one (1) inch or equal to the OD of the tremie pipe whichever is greater. Permanent tremie pipes will be considered as a casing string and subject to minimum annular space requirements in addition to the annular space requirements around the well casing (Figure 03, Appendix A). (5-8-09)

ii. All grout seals must be placed from the bottom up, by using an approved method. Bentonite grout must not be used above the water table unless specifically designed and manufactured for such use and approved by the Director in advance. (5-8-09)

iii. If cement-based grout (neat cement or neat cement grout) is used to create a seal, the casing string sealed must not be moved or driven after the initial set. Construction must not resume for a minimum of twenty-four (24) hours following seal placement; (5-8-09)

g. For dry bentonite seals the minimum annular space required must provide for a uniform seal thickness not less than one and five-eighths (1 5/8) inches on all sides of the casing or a borehole at least four (4) inches larger than the "nominal diameter" of the casing to be sealed. e.g., (six and five-eighths (6 5/8) inch OD (six (6) inch nominal) casing requires a ten and three fourths (10 3/4) inch OD (ten (10) inch nominal) temporary casing or a nine and seven-eighths (9 7/8) inch (ten (10) inch nominal) minimum borehole). Listed below are additional annular space requirements and limitations for placement of dry bentonite seals: (5-8-09)

i. All dry bentonite seals must be tagged during placement and consider volumetric calculations to verify placement. (5-8-09)

ii. Installation of dry bentonite seals must be consistent with the manufacturers' recommendations and specifications for application and placement. (5-8-09)

iii. Granular bentonite must not be placed through water. (5-8-09)

iv. If a granular bentonite seal is placed deeper than two hundred (200) feet, the minimum annular space must be increased by at least one (1) inch e.g., (six and five-eighths (6 5/8) inch OD (six (6) inch nominal) casing requires a twelve and three fourths (12 3/4) inch OD (twelve (12) inch nominal) temporary casing or an eleven and seven eights (11 7/8) inch (twelve (12) inch nominal) minimum borehole). (5-8-09)

v. Bentonite chips may be placed through water or drilling fluid of appropriate viscosity. Bentonite chip seals placed through more than fifty (50) feet of water or drilling fluid will require the minimum annular space to be increased by at least one (1) inch e.g., (six and five-eighths (6 5/8) inch OD (six (6) inch nominal) casing requires a twelve and three fourths (12 3/4) inch OD (twelve (12) inch nominal) temporary casing or an eleven and seven eights (11 7/8) inch (twelve (12) inch nominal) minimum borehole). (5-8-09)

08. Sealing of Wells. Sealing requirements described herein are minimum standards that apply to all wells. The Director may establish alternate minimum sealing requirements in specific areas when it can be determined through detailed studies of the local hydrogeology that a specific alternate minimum will provide protection of the ground water from waste and contamination. (5-8-09)

a. Consolidated Formations. When a water well is drilled into and acquires water from an aquifer that consists of consolidated formations that are above the water table, casing must be installed so that it extends and is sealed to a depth not less than thirty-eight (38) feet (Figure 04, Appendix A). If the well depth is less than thirty-eight (38) feet from land surface, well casing must be installed and sealed five (5) feet into the consolidated formation or to a depth of eighteen (18) feet, whichever is greater. (5-8-09)

b. Unconsolidated Formations without Confining Layers of Clay. When a water well is drilled into and acquires water from an unconfined aquifer that is overlain with unconsolidated formations, such as sand and gravel without confining layers of clay, well casing must extend to at least five (5) feet below the water table and be sealed to a depth not less than thirty-eight (38) feet (Figure 05, Appendix A). If the well depth is less than thirty-eight (38) feet well casing must extend to at least five (5) feet below the water table or eighteen (18) feet, whichever is greater, and be sealed to a depth of at least eighteen (18) feet. (5-8-09)

i. The extensive (for example, one hundred fifty (150) feet thick or more) unconsolidated, non-stratified, sand and gravel of the Rathdrum Prairie are characterized by extremely high transmissivity and hydraulic conductivity. Under these conditions, sealing wells to depths greater than eighteen (18) feet may not be additionally protective. When a water well is drilled within the boundaries of the Rathdrum Prairie, (shown in Figure 06, Appendix A of these rules), well casing must extend to at least five (5) feet below the water table and be sealed to a depth not less than eighteen (18) feet (Figure 07, Appendix A). (5-8-09)

c. Unconsolidated Formations with Confining Layers of Clay. When a well is drilled into and acquires water from an aquifer that is overlain by unconsolidated deposits such as sand and gravel, and there are confining layers of clay above the water table, well casing must be installed from the land surface to the confining layer immediately above and in contact with the production zone and sealed to a depth not less than thirty-eight (38) feet (Figure 08, Appendix A). If the well depth is less than thirty-eight (38) feet from land surface, well casing must extend and be sealed into the first confining layer or to a depth of eighteen (18) feet, whichever is greater. (5-8-09)

09. Sealing Artesian Wells. (5-8-09)

a. Unconsolidated Formations. When artesian water is encountered in unconsolidated formations, the production zone or open interval must be limited to zones of like pressure, temperature, and quality. Water encountered in oxidized sediments must not be comingled with water encountered in reduced sediments. Well casing must extend from land surface into the lower most confining layer above the production zone, and must be sealed: (5-8-09)

i. From land surface to a depth of at least thirty-eight (38) feet; and (5-8-09)

ii, Through all confining layer(s); and (5-8-09)

(1) A minimum of five (5) feet of seal material must be placed into or through the lower most confining layer above the production zone (Figure 09, Appendix A); or (5-8-09)

(2) Five (5) feet into or through the lowermost confining layer above the production zone and continuously to land surface (Figure 09, Appendix A). (5-8-09)

iii. If the well depth is less than thirty-eight (38) feet, the well must be cased and sealed from land surface to the confining layer in direct contact with the production zone or to a depth of eighteen (18) feet, whichever is greater. (5-8-09)

b. Consolidated Formations. When artesian water is encountered in a consolidated formation, well casing must be installed and sealed from land surface to a depth of at least thirty-eight (38) feet; and (5-8-09)

i. If the consolidated formation is overlain by a permeable formation(s) and water will rise above the consolidated formation, well casing must extend and be sealed at least five (5) feet into the confining portion of the consolidated formation (Figure 10, Appendix A). (5-8-09)

ii. If the well depth is less than thirty-eight (38) feet, the well must be cased and sealed from land surface five (5) feet into the confining consolidated formation or to a depth of eighteen (18) feet, whichever is greater. (5-8-09)

c. Control Device. Pursuant to Section 42-1603, Idaho Code, if the well flows at land surface, it must be equipped with a control device approved by the Director, so that the flow can be completely stopped. If leaks occur around the well casing or adjacent to the well, the well must be completed with seals, casing or cement grout to eliminate the leakage. (5-8-09)

i. Flowing artesian wells must be equipped with an approved pressure gage fitting that will allow access for measurement of shut-in pressure of a flowing well. All pressure gage fittings must include control valves such that the pressure gage can be removed without resulting in artesian flow from the well. (5-8-09)

ii. The well driller must not move his well drilling rig from the site until all requirements have been satisfied. Some mixing of water may be allowed to develop an adequate water well; however, the mixing must be restricted to water zones of similar pressure, temperature and quality. The driller must take precautions to case and seal out zones which may lead to waste or contamination. (5-8-09)

10. Alternative Methods for Sealing Wells. To accommodate for new technology, and in consideration of the wide variety of drilling equipment used to construct wells, other methods of sealing wells not specifically addressed in these rules may be allowed. The Director may consider specific proposals for alternative methods of sealing on a case by case basis. Director approval or acceptance of such procedures will not constitute a "waiver" of any requirements of these rules. In such cases, the well driller must provide sufficient information for the Director to determine that the full intent of the sealing requirements will be satisfied if an alternative method is employed. If it is determined that a specific alternate method will provide protection of the ground water from waste and contamination, the Director may issue a statement of acceptance qualifying the use and implementation of such methods. (5-8-09)

11. Injection Wells. In addition to meeting the requirements of Rule 25 of these rules, the construction, modification, or decommissioning (abandonment) of all injection wells over eighteen (18) feet in vertical depth must also comply with the IDAPA 37.03.03, "Rules for the Construction and Use of Injection Wells," and the injection well permit. Drillers must obtain from the Director a certified copy of the permit authorizing construction or modification of an injection well before beginning work. (5-8-09)

12. Cathodic Protection Wells. All cathodic protection wells must be constructed by a licensed well driller in compliance with these rules. A detailed construction plan must be included with the drilling permit application. (5-8-09)

13. Monitoring and Remediation Wells. All monitoring wells and remediation wells must be constructed and maintained in a manner that will prevent waste or contamination and as otherwise required by these rules. When a monitoring well or a remediation well is no longer useful or needed, the owner or operator of the well must decommission (abandon) the well in accordance with Rule 25, Subsection 025.16 of these rules. No person may divert ground water from a monitoring well or a remediation well for any purpose not authorized by the Director. The application for a permit for all monitoring wells and all remediation wells must include a design proposal prepared by a licensed engineer or registered geologist pursuant to Section 42-235, Idaho Code. Blanket permits for monitoring well and remediation well networks may be approved for site-specific monitoring and remediation programs. The designs and specification for monitoring wells and remediation wells must demonstrate that: (5-8-09)

a. The ground water resources are protected against waste and contamination; (5-8-09)

b. The well(s) will inject or withdraw only fluids, gasses or solutions approved by the Director; (5-8-09)

c. The well(s) will be constructed so as to prevent aquifer commingling; and (5-8-09)

d. The well(s) will be properly decommissioned (abandoned) upon project completion and in accordance with these rules. (5-8-09)

14. **Closed Loop Heat Exchange Wells**. The well driller must construct closed loop heat exchange wells consistent with these rules. The well driller is not required to install steel casing in such wells. When constructing a closed loop heat exchange well, the well driller must: (5-8-09)

a. Construct each borehole of sufficient size to provide the annular space required by these rules. (5-8-09)

b. Seal the annular space of each borehole with approved seal material in accordance with these rules; (5-8-09)

c. Install fluid-tight circulating pipe, composed of high-density polyethylene, grade PE3408, minimum cell classifications PE355434C or PE345434C conforming to ASTM Standard D3350, or other Director-approved pipe; (5-8-09)

d. Join pipe using thermal fusion techniques according to ASTM Standards D-3261 or D-2683. All personnel creating such system joints must be trained in the appropriate thermal fusion technologies; (5-8-09)

e. Use only propylene glycol, or other circulating fluid approved by the Director; (5-8-09)

f. Ensure that any other system additive is NSF approved and has prior approval from the Director; (5-8-09)

g. Pressure test each loop with potable water prior to grout installation; (5-8-09)

h. Pressure test the system with potable water prior to installation of the circulating fluid at one hundred percent (100%) of the designed system operating pressure for a minimum duration of twenty-four (24) hours; and (5-8-09)

i. Properly repair or decommission (abandon) all loops failing the test by pressure pumping approved seal material through the entire length of each failed loop. After grouting, loop ends must be fused together or capped. (5-8-09)

15. **Access Port or Pressure Gage**. Upon completion of a well and before removal of the well rig from the site, the well must be equipped with an access port that will allow for measurement of the depth to water or an approved pressure gage fitting that will allow access for measurement of shut-in pressure of an artesian flowing well. All pressure gage fittings must include control valves such that the pressure gage can be removed. Approved access ports are illustrated in Figure 11, APPENDIX A, together with approved locations for pressure gage fittings. Air lines are not a satisfactory substitution for an access port. Nonflowing domestic and stock water wells that are to be equipped with a sanitary seal with a built-in access port are exempt from this requirement. (5-8-09)

16. **Decommissioning (Abandoning) of Wells**. (5-8-09)

a. The well owner is charged with maintaining and properly decommissioning (abandoning) a well in a manner that will prevent waste or contamination, or both, of the ground water. No person is allowed to decommission a well in Idaho without first obtaining a driller's license or receiving a waiver of the license requirement from the Director of the Department of Water Resources. Authorization is required from the Director prior to decommissioning any well. Upon decommissioning, the person who decommissioned the well must submit to the Director a report describing the procedure. (5-8-09)

b. The Director may require decommissioning of a well in compliance with the provisions of these rules, if the well: (5-8-09)

i. Does not meet minimum well construction standards; (5-8-09)

ii. Meets the definition of an unusable well; (5-8-09)

iii. Poses a threat to human health and safety; (5-8-09)

iv. Is in violation of IDAPA 58.01.11, "Ground Water Quality Rule"; or (5-8-09)

v. Has no valid water right or other authorization acceptable to the Director for use of the well. (5-8-09)

c. When required by the Director, decommissioning must be done in accordance with the following: (5-8-09)

i**.** Cased wells and boreholes without a continuous seal from the top of the intakes or screen to the surface. The well driller must use one (1) of the following methods as applicable: (5-8-09)

(1) The Director may require that well casing be perforated every five (5) feet from the bottom of the casing to within five (5) feet of the surface. Perforations made must be adequate to allow the free flow of seal material into any voids outside the well casing. There must be at least four equally spaced perforations per section circumference. Approved grout must be pressure pumped to fill any voids outside of the casing. A sufficient volume must be used to completely fill the well and annular space; or (5-8-09)

(2) Fill the borehole with approved seal material as the casing is being removed. (5-8-09)

ii**.** Cased wells and boreholes with full-depth seals. If the well is cased and sealed from the top of the screen or production zone to the land surface, the well must be completely filled with approved seal material. (5-8-09)

iii**.** Uncased wells must be completely filled with approved seal material. (5-8-09)

iv. Dry hole wells or wells from which the quantity of water to meet a beneficial use cannot be obtained must be decommissioned with cement grout, concrete or other approved seal material in accordance with these rules. (5-8-09)

17. Completion of a Well. The Director will consider that every well is completed when the well drilling equipment has been removed, unless written notice has been given to the Director by the well driller that he intends to return and do additional work on the well within a specified period of time. Upon completion of the well, the well must meet all of the required standards. (5-8-09)

a. Upon completion of drilling and prior to removal of well drilling equipment from a water well site, the top of the casing must be completely covered with: (5-8-09)

i. A one-fourth inch (1/4") thick solid, new or like-new steel plate with a three-fourths inch (3/4) threaded and plugged access port, welded to and completely covering the casing (Figure 12, Appendix A); or (5-8-09)

ii. A threaded cap, or a commercially manufactured watertight sanitary well cap (Figure 12, Appendix A); or (5-8-09)

iii. A commercially manufactured water-tight, snorkel-vented or non-vented well cap on any well susceptible to submergence; or (5-8-09)

iv. A control device approved by the Director per Section 42-1603, Idaho Code, on any well that flows at land surface (Figure 11, Appendix A). (5-8-09)

b. Upon the completion of every well, the well driller must permanently affix the stainless steel well tag to the steel surface casing in a manner and location that maintains tag legibility. For closed loop heat exchange wells, the well driller must obtain approval for the well tag placement and method of attachment. The well driller must secure each tag by: (5-8-09)

i. A full-length weld across the top and down each side of the tag; or (5-8-09)

ii. Using one (1) stainless steel, closed-end domed rivet near each of the four (4) corners of the tag. (5-8-09)

iii. Prior to welding or riveting, the tag must be pre-shaped to fit the casing such that both sides to be welded or riveted touch the casing and no gaps exist between the tag and casing. (5-8-09)

18. Pitless Adapters. When a pitless adaptor is used (Figure 12, Appendix A), the adaptor should be of the type approved by the NSF International testing laboratory or the approval code adopted by the Pitless Adaptor Division of the Water Systems Council. The pitless adaptor, including the cap or cover, casing extension, and other attachments, must be so designed and constructed to be water tight and to prevent contamination of the potable water supply from external sources. If a permanent surface or outer casing is installed and is cut off or breached to install the pitless adapter on an inner well casing or liner, the space between the permanent outer casing and the liner or inner casing must be sealed. The well owner or person installing the pitless adaptor must then seal the excavation surrounding the pitless adaptor using an approved seal material. (5-8-09)

19. Pump Installation. No person is allowed to install a pump into any well that would cause a violation of Rule 25, of these rules or other applicable rules or state law. (5-8-09)

20. Explosives. Explosives used in well construction must never be detonated inside the required well casing. Approved explosive casing perforators may be exempted by the Director. (5-8-09)

21. Hydraulic Fracturing. Hydraulic fracturing must be performed only by well drillers licensed in Idaho. The pressure must be transmitted through a drill string and must not be transmitted to the well casing. The driller must provide a report to the Director of the fracturing work which must include well location, fracturing depth, fracturing pressures and other data as requested by the Director. (5-8-09)

22. Drilling Fluids or Drilling Additives. The well driller must use only potable water and drilling fluids or drilling additives that are manufactured for use in water wells, are NSF International, American Petroleum Institute (API), or ASTM/ANSI approved; and do not contain a concentration of any substance in excess of Primary Drinking Water Standards, as set forth in IDAPA 58.01.08, "Rules for Public Drinking Water Systems," according to manufacturer's specifications. The well driller may seek approval from the Director to use specific, non-certified products on a case-by-case basis. In addition, the well driller must ensure the containment of all drilling fluids and materials used or produced to the immediate drilling site, and will not dispose of such fluids or materials into any streams, canals, boreholes, wells, or other subsurface pathways. (5-8-09)

23. Disinfection and Decontamination. Upon completion of a well, the driller is responsible for adding the appropriate amount of disinfecting chemical compound and distributing it throughout the well to achieve a uniform concentration for "in place" disinfection of the well. Chlorine compounds used in accordance with the table listed below will satisfy this requirement. Other methods may be used if approved by the Director in advance.

Amount of Chlorine Needed Per 100 Feet of Water in Well			
Casing Diameter (in.)	Gallons of water in casing per 100 ft. of water depth	Amount of 5.25% Sodium Hypochlorite (Unscented Laundry Bleach)	Amount of 65% Calcium Hypochlorite (Chlorine Granules)
6	147	2 ¼ cups	3 tbsp
8	261	4 cups	5 tbsp
10	408	6 ¼ cups	½ cup
12	588	9 cups	¾ cup
16	1044	1 gal	1 ¼ cup
Note: 1 gal = 4 qt = 8 pt = 16 cups; 1 cup = 16 tbsp			
Chlorine granules or tablets must be dissolved and placed into the well as a solution.			
If another concentration of hypochlorite solution is used, the following equation should be used for calculating amounts. (Volume of water in gallons) X (0.08) / % Hypochlorite (e.g. 50% = 50) = cups of hypochlorite Example: To treat 147 gallons of water using a 50% concentration of hypochlorite solution: (147 gallons water) X (0.08) / 50 = .23 (or approximately 1/4) cup of 50% Hypochlorite solution			

(5-8-09)

24. **Sand Production**. The maximum sand content produced from a well after initial well development must not exceed fifteen (15) ppm. For the purpose of this rule, sand is considered to be any sediment particle retained on a U.S. standard sieve #200 (seventy-five hundreths (0.075) mm to two (2) mm). (5-8-09)

a. When necessary to mitigate sand production the well driller must: (5-8-09)

i. Construct each well with properly sized casing, screen(s) or perforated intake(s); and (5-8-09)

ii. Install properly sized filter pack(s); or (5-8-09)

iii. Install pre-packed well screens; or (5-8-09)

iv. Employ other methods approved by the Director. (5-8-09)

b. The Director may grant a waiver exempting a well producing water that exceeds the maximum sand content only if the well driller has met the requirements of Rule 25, Subsection 025.24.a. (5-8-09)

c. Sand production in public water system wells. Wells used in connection with a public water system have more stringent requirements. See IDAPA 58.01.08, “Idaho Rules for Public Water Systems.” (5-8-09)

25. **Well Development and Testing**. For each well the well driller must measure and record the static (non-pumping) water level and the pumping water level, and the production rate. The production rate will be determined by a pump, bailer, air-lift, or other industry approved test of sufficient duration to establish production from the well. For wells with no returns the driller must report no returns and the static water level. This information must be documented on the well driller’s report. (5-8-09)

026. -- 029. (RESERVED)

030. CONSTRUCTION OF LOW TEMPERATURE GEOTHERMAL RESOURCE WELLS AND BONDING (RULE 30).

01. General. Drillers constructing low temperature geothermal resource wells (bottom hole temperature more than eighty-five (85) degrees Fahrenheit and less than two hundred twelve (212) degrees Fahrenheit) must be qualified under the Well Driller Licensing Rules. All low temperature geothermal resource wells must be constructed in such a manner that the resource will be protected from waste due to lost artesian pressure and temperature. The owner or well driller is required to provide bottom hole temperature data, but the Director may make the final determination of bottom hole temperature, based upon information available to him. (5-8-09)

a. All standards and guidelines for construction and decommissioning (abandonment) of cold water wells apply to low temperature geothermal resource wells except as modified by Rule 30, Subsections 030.03, 030.04, and 030.06. (5-8-09)

b. A drilling prospectus must be submitted to and approved by the Director prior to the construction, modification, deepening or decommissioning (abandonment) of any low temperature geothermal resource well. The well owner and the well driller are responsible for the prospectus and subsequent well construction. (5-8-09)

02. Well Owner Bonding. The owner of any low temperature geothermal resource well must file a surety bond or cash bond as required by Section 42-233, Idaho Code, with the Director in an amount not less than five thousand dollars ($5,000) nor more than twenty thousand dollars ($20,000) payable to the Director prior to constructing, modifying or deepening the well after July 1, 1987. The bond amount will be determined by the Director within the following guidelines. The bond will be kept in force for one (1) year following completion of the well or until released in writing by the Director, whichever occurs first. (5-8-09)

a. Any well less than three-hundred (300) feet deep with a bottom hole temperature of less than one hundred twenty (120) degrees Fahrenheit and a shut-in pressure of less than ten (10) pounds per square inch gage (psig) at land surface must maintain a bond of five thousand dollars ($5,000). (5-8-09)

b. The owner of any well three hundred (300) feet to one thousand (1,000) feet deep with a bottom hole temperature of less than one hundred fifty (150) degrees Fahrenheit and a shut-in pressure of less than fifty (50) psig at land surface must maintain a bond of ten thousand dollars ($10,000). (5-8-09)

c. The owner of any low temperature geothermal resource well not covered by Rule 30, Subsections 030.02.a. and 030.02.b. must maintain a bond of twenty thousand dollars ($20,000). (5-8-09)

d. The Director may decrease or increase the bonds required if it is shown to his satisfaction that well construction or other conditions merit an increase or decrease. (7-1-93)

e. The bond requirements of Section 42-233, Idaho Code, are applicable to wells authorized by water right permits or licenses having a priority date earlier than July 1, 1987, if the well authorized by the permit or license was not constructed prior to July 1, 1987 or if an existing well constructed within the terms of the permit or license is modified, deepened or enlarged on or after July 1, 1987. (7-1-93)

03. Casing. Low temperature geothermal resource wells must be properly cased and sealed to protectfrom cooling by preventing intermingling with cold water aquifers. (5-8-09)

a. Steel casing which meets or exceeds the minimum specifications for permanent steel casing of Rule 25, Subsection 025.04 must be installed in every well. The Director may require a more rigid standard for collapse and burst strength as depths or pressures may dictate. Every low temperature geothermal resource well which flows at land surface must have a minimum of forty (40) feet of conductor pipe set and cemented its entire length. (5-8-09)

b. Casing must be installed from twelve (12) inches above land surface into the overlying confining strata of the thermal aquifer. The casing schedule may consist of several different casing strings (i.e. conductor pipe, surface casing, intermediate casing, production casing) which may all extend to land surface or may be overlapped and sealed or packed to prevent fluid migration out of the casing at any depth (Figure 13, Appendix A). (5-8-09)

i. Low temperature geothermal resource wells less than one thousand (1,000) feet deep and which encounter a shut-in pressure of less than fifty (50) psig at land surface must have two (2) strings of casing set and cemented to land surface. Conductor pipe must be a minimum of forty (40) feet in length or ten percent (10%) of the total depth of the well whichever is greater. Surface casing must extend into the confining stratum overlying the aquifer. (5-8-09)

ii. Low temperature geothermal resource wells one thousand (1,000) feet or more in depth or which will likely encounter a shut-in pressure of fifty (50) psig or more at land surface require prior approval of the drilling plan by the Director and must have three strings of casing cemented their total length to land surface. Conductor pipe must be a minimum length of forty (40) feet. Surface casing must be a minimum of two hundred (200) feet in length or ten percent (10%) of the total depth of the well, whichever is greater. Intermediate casing must extend into the confining stratum overlying the aquifer. (5-8-09)

c. Subsection 030.03.b. may be waived if it can be demonstrated to the Director through the lithology, electrical logs, geophysical logs, injectivity tests or other data that formations encountered below the last casing string set, will neither accept nor yield fluids at anticipated pressure to the borehole. (5-8-09)

d. A nominal borehole size of two (2) inches in diameter larger than the Outside Diameter (O.D.) of the casing or casing coupler (whichever is larger) must be drilled. All casing designations must be by O.D. and wall thickness and must be shown to meet a given specification of the American Petroleum Institute, the American Society for Testing and Materials, the American Water Works Association or the American National Standards Institute. The last string of casing set during drilling operations must, at the Director's option, be flanged and capable of mounting a valve or blow out prevention equipment to control flows at the surface before drilling resumes. (5-8-09)

04. Sealing of Casing. All casing must be sealed its entire length with cement or a cement grout mixture unless waived by the Director. The seal material must be placed from the bottom of the casing to land surface either through the casing or tubing or by use of a tremie pipe. The cement or cement grout must be undisturbed for a minimum of twenty-four (24) hours or as needed to allow adequate curing. (5-8-09)

a. A caliper log may be run for determining the volume of cement to be placed with an additional twenty-five (25%) percent on site ready for mixing. If a caliper log is not run, an additional one hundred (100%) percent of the calculated volume of cement must be on site ready for placement. (5-8-09)

b. If there is no return of cement or cement grout at the surface after circulating all of the cement mixture on site, the Director will determine whether remedial work should be done to insure no migration of fluids around the well bore. (5-8-09)

c. The use of additives such as bentonite, accelerators, retarders, and lost circulation material must follow manufacturer's specifications. (5-8-09)

05. Blow Out Prevention Equipment. The Director may require the installation of gate valves or annular blow out prevention equipment to prevent the uncontrolled blow out of drilling mud and geothermal fluid. (7-1-93)

06. Repair of Wells. The well driller must submit a drilling prospectus to the Director for review and approval prior to the repair or modification of a low temperature geothermal resource well. (5-8-09)

07. Decommissioning (Abandoning) of Wells. Proper decommissioning (abandonment) of any low temperature geothermal resource well requires the following: (5-8-09)

a. All cement plugs must be pumped into the hole through drill pipe or tubing. (5-8-09)

b. All open annuli must be completely filled with cement. (5-8-09)

c. A cement plug at least one hundred (100) feet in vertical depth must be placed straddling (fifty (50) feet above and fifty (50) feet below) the zone where the casing or well bore meets the upper boundary of each ground water aquifer. (5-8-09)

d. A minimum of one hundred (100) feet of cement must be placed straddling each drive shoe or guide shoe on all casing including the bottom of the conductor pipe. (5-8-09)

e. A surface plug of either cement grout or concrete must be placed from at least fifty (50) feet below the top of the casing to the top of the casing. (5-8-09)

f. A cement plug must extend at least fifty (50) feet above and fifty (50) feet below the top of any liner installed in the well. The Director may waive this rule upon a showing of good cause. (5-8-09)

g. Other decommissioning (abandonment) procedures may be approved by the Director if the owner or operator can demonstrate that the low temperature geothermal resource, ground waters, and other natural resources will be protected. (5-8-09)

h. Approval for decommissioning (abandonment) of any low temperature geothermal well must be in writing by the Director prior to the beginning of any decommissioning (abandonment) procedures. (5-8-09)

031. -- 034. (RESERVED)

035. HEALTH STANDARDS (RULE 35).

01. Public Water System Wells. In addition to meeting these standards, all wells that are constructed for public supply of domestic water must meet all of the requirements set forth by the Idaho Department of Environmental Quality Rules, IDAPA 58.01.08, “Idaho Rules for Public Drinking Water Systems.” (5-8-09)

02. Special Standards for Construction of Wells When Mineralized or Contaminated Water Is Encountered. Any time in the construction of a well that mineralized or contaminated water is encountered, the well driller must take the appropriate steps necessary to prevent the poor quality waters from entering the well or moving up or down the annular space around the well casing. The method employed to case and seal out this water will be determined by the well driller, provided all other minimum standards are met. The well driller will take special precautions in the case of filter-packed wells to prevent water of inferior quality from moving vertically in the filter packed portions of the well. All actions taken will be clearly documented on the well driller’s report. (5-8-09)

03. Distances From Contaminant Sources. All water wells constructed for domestic use must comply with minimum distances from septic tanks, drain fields, drainfield replacement area and other siting requirements as set forth in Rule 25, Subsection 025.01.d. (5-8-09)

036. OWNERS RESPONSIBILITIES FOR WELL USE AND MAINTENANCE (RULE 36).
After a well is completed the well owner is responsible for water quality testing, properly maintaining the well, and reporting problems with a well to the Director. All wells must be capped, covered and sealed such that debris cannot enter the well, persons or animals cannot fall into the well, and water cannot enter the well around the outside of the casing. Pursuant to Section 42-1603, Idaho Code, the owner of any artesian well that will flow at land surface is required to apply to the Director for approval of a flow control device. (5-8-09)

01. Use. The well owner must not operate any well in a manner that causes waste or contamination of the ground water resource. Failure to operate, maintain, knowingly allow the construction of any well in a manner that violates these rules, or failure to repair or properly decommission (abandon) any well as herein required will subject the well owner to civil penalties as provided by statute. (5-8-09)

02. Maintenance. The well owner must: (5-8-09)

a. Not allow modification to wells under their control without first obtaining an approved Idaho Department of Water Resources (IDWR) permit, pursuant to Section 42-235, Idaho Code; (5-8-09)

b. Maintain the minimum casing height of twelve (12) inches above land surface and finished grade; (5-8-09)

c. Maintain the appropriate well cap, and control device if required, according to these Rules; and (5-8-09)

d. Not install or allow the installation of any well pump that would cause a violation of the sand production requirements in accordance with these Rules or allow the well to pump in excess of that allowed by a valid water right or domestic exemption. (5-8-09)

e. Maintain the well to prevent waste or contamination of ground waters through leaky casings, pipes, fittings, valves, pumps, seals or through leakage around the outside of the casings, whether the leakage is above or below the land surface. Any person owning or controlling a non-compliant well must have the well repaired by a licensed well driller under a permit issued by the Director in accordance with these Rules. (5-8-09)

03. New Construction. The well owner must not construct or allow construction of any permanent building, except for buildings to house a well or plumbing apparatus, or both, closer than ten (10) feet from an existing well. (5-8-09)

04. Maintain All Other Separation Distances. The well owner must not construct or install, or allow the construction or installation of any object listed in a location closer than that allowed by the table of Rule 25, Subsection 025.01.d. (5-8-09)

05. Unusable Wells. The well owner must have any unusable well repaired or decommissioned (abandoned) by a licensed well driller under a permit issued by the Director in accordance with these Rules. (5-8-09)

06. Wells Posing a Threat to Human Health and Safety or Causing Contamination of the Ground Water Resource. The well owner must have any well shown to pose a threat to human health and safety or cause contamination of the ground water resource immediately repaired or decommissioned (abandoned) by a licensed well driller under a permit issued by the Director in accordance with these Rules. (5-8-09)

037. -- 039. (RESERVED)

040. AREAS OF DRILLING CONCERN (RULE 40).

01. General. (7-1-93)

a. The Director may designate an "area of drilling concern" to protect public health, or to prevent waste and contamination of ground or surface water, or both, because of factors such as aquifer pressure, vertical depth to the aquifer, warm or hot ground water, or contaminated ground or surface waters. (7-1-93)

b. The designation of an area of drilling concern does not supersede or preclude designation of part or all of an area as a Critical Ground Water Area (Section 42-233a, Idaho Code), Ground Water Management Area (Section 42-233b, Idaho Code), or Geothermal Resource Area (Sections 42-4002 and 42-4003, Idaho Code). (7-1-93)

c. The designation of an area of drilling concern can include certain aquifers or portions thereof while excluding others. The area of drilling concern may include low temperature geothermal resources while not including the shallower cold ground water systems. (7-1-93)

02. Bond Requirement. (7-1-93)

a. The minimum bond to be filed by the well driller with the Director for the construction or modification of any well in an area of drilling concern is ten thousand dollars ($10,000) unless it can be shown to the satisfaction of the Director that a smaller bond is sufficient. (5-8-09)

b. The Director may determine on a case-by-case basis if a larger bond is required based on the estimated cost to repair, complete or properly decommission (abandon) a well. (5-8-09)

03. Additional Requirements. (7-1-93)

a. A driller must demonstrate to the satisfaction of the Director that he has the experience and knowledge to adequately construct or decommission (abandon) a well which encounters warm water or pressurized aquifers. (5-8-09)

b. A driller must demonstrate to the satisfaction of the Director that he has, or has immediate access to, specialized equipment or resources needed to adequately construct or decommission (abandon) a well. (5-8-09)

041. -- 044. (RESERVED)

045. DRILLING PERMIT REQUIREMENTS (RULE 45).

01. General Provisions. (7-1-93)

a. Drilling permits are required pursuant to Section 42-235, Idaho Code, prior to construction or modification of any well. (5-8-09)

b. Drilling permits will not be issued for construction of a well which requires another separate approval from the department, such as a water right permit, transfer, amendment or injection well permit, until the other separate permitting requirements have been satisfied. (5-8-09)

c. The Director may allow the use of a start card permit or give verbal approval to a well driller for the construction of cold water single family domestic wells. Start cards must be received by the Department at least two office hours prior to commencing construction of the well. (5-8-09)

d. The Director may give verbal approval to a well driller for the construction of a well for which other permitting requirements have been met, provided that the driller or owner has filed the drilling permit application and appropriate fee. (5-8-09)

e. The Director will not give a verbal approval or allow the use of a start card permit for wells constructed in a designated Area of Drilling Concern, Critical Ground Water Area, or Ground Water Management Area. (5-8-09)

f. A well driller will not construct, drill or modify any well until a drilling permit has been issued, or verbal approval granted. (5-8-09)

02. Effect of a Permit. (7-1-93)

a. A drilling permit authorizes the construction or modification of a well in compliance with these rules and the conditions of approval on the permit. (5-8-09)

b. A drilling permit does not constitute a water right, injection well permit or other authorization which may be required, authorizing use of water from a well or discharge of fluids into a well. (5-8-09)

c. A drilling permit may not be assigned from one owner to another or from one driller to another. (5-8-09)

d. A drilling permit authorizes the construction of one (1) well, except for blanket monitoring well and blanket remediation well drilling permits. (5-8-09)

03. Exclusions.For the purposes of these Rules, artificial openings and excavations that do not constitute a well and are not subject to the drilling permit requirements must be modified, constructed, or decommissioned (abandoned) in accordance with minimum well construction standards. The Director may require decommissioning (abandonment) of artificial openings and excavations constructed pursuant to Rule 45, Subsection 045.03 of these rules, when the use ceases or if the holes may contribute to waste or contamination of the ground water. The following types of artificial openings and excavations are not considered wells: (5-8-09)

a. Artificial openings and excavations with total depth less than eighteen (18) feet. (5-8-09)

b. Artificial openings and excavations for collecting soil or rock samples, determining geologic properties, or mineral exploration or extraction, including gravel pits. (5-8-09)

c. Artificial openings and excavations for oil and gas exploration for which a permit has been issued pursuant to Section 47-320, Idaho Code. (5-8-09)

d. Artificial openings and excavations constructed for de-watering building or dam foundation excavations. (5-8-09)

04. Converting an Artificial Openings or Excavations Not Constructed as a Well for Use as a Well. Artificial openings and excavations that were not constructed as a well pursuant to a drilling permit, if subsequently converted to obtain water, monitor water quantity or quality, or to dispose of water or other fluids, must be reconstructed by a licensed driller in compliance with well construction standards and drilling permit requirements. (5-8-09)

05. Fees. (7-1-93)

a. Drilling permit fees are as prescribed by Section 42-235, Idaho Code. (5-8-09)

b. The difference between the drilling permit fee required by Section 42-235 Idaho Code as applicable, must be paid when an existing well constructed on or after July 1, 1987, for which the lower drilling permit fee was paid, is authorized by the Director for a use which would require the larger drilling permit fee. (5-8-09)

046. -- 049. (RESERVED)

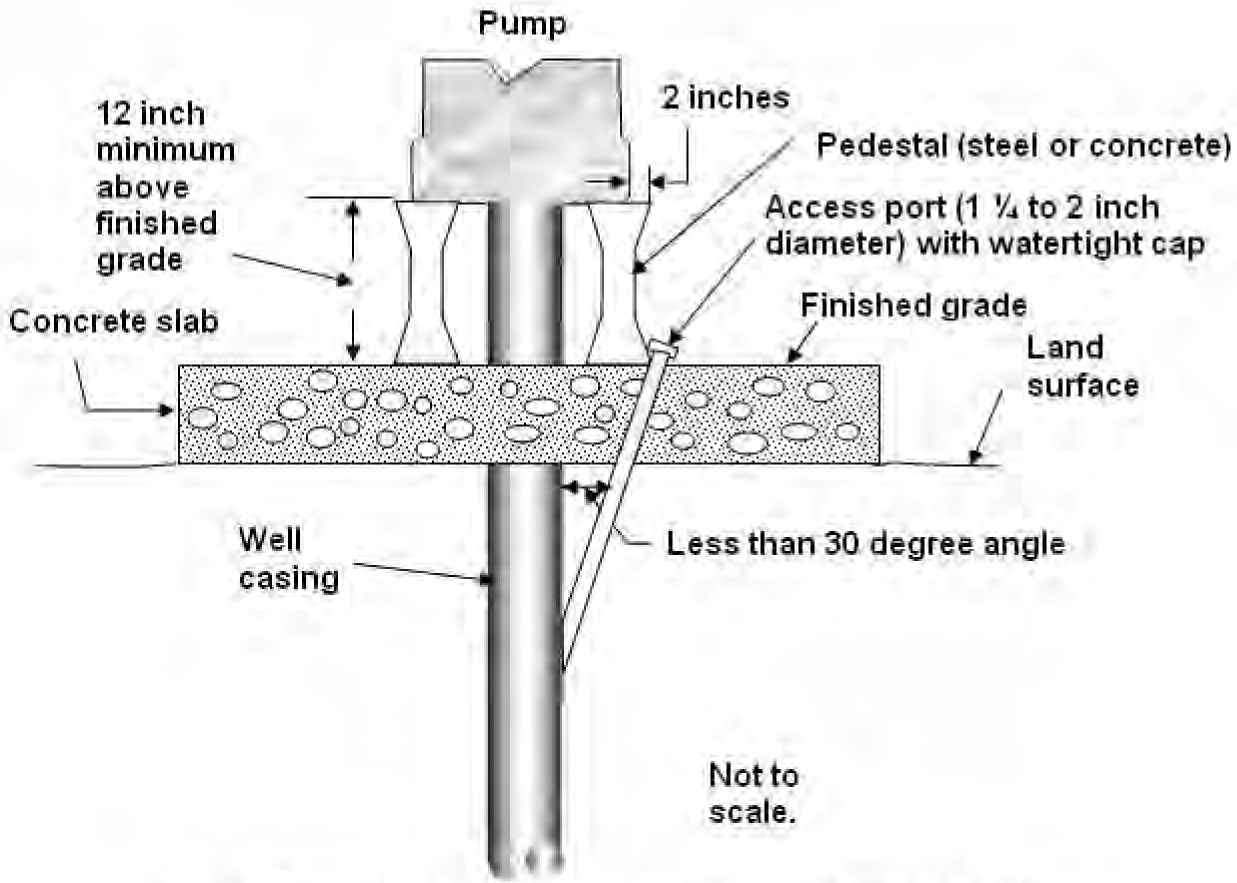
050. PENALTIES (RULE 50).

A person owning or controlling a well that allows waste or contamination of the state's ground water resources or causes a well not to meet the construction standards provided in these Rules is subject to the civil penalties as provided by statute. A driller who violates the foregoing provisions of these well construction standards Rules is subject to enforcement action and the penalties as provided by Statute. (5-8-09)

051. -- 999. (RESERVED)

APPENDIX A

Figure 01. Concrete Slabs and Finished Grade



Note. Pedestal shall not extend more than two (2) inches past pump base in horizontal direction.

Figure 02. Annular Space and Overbore

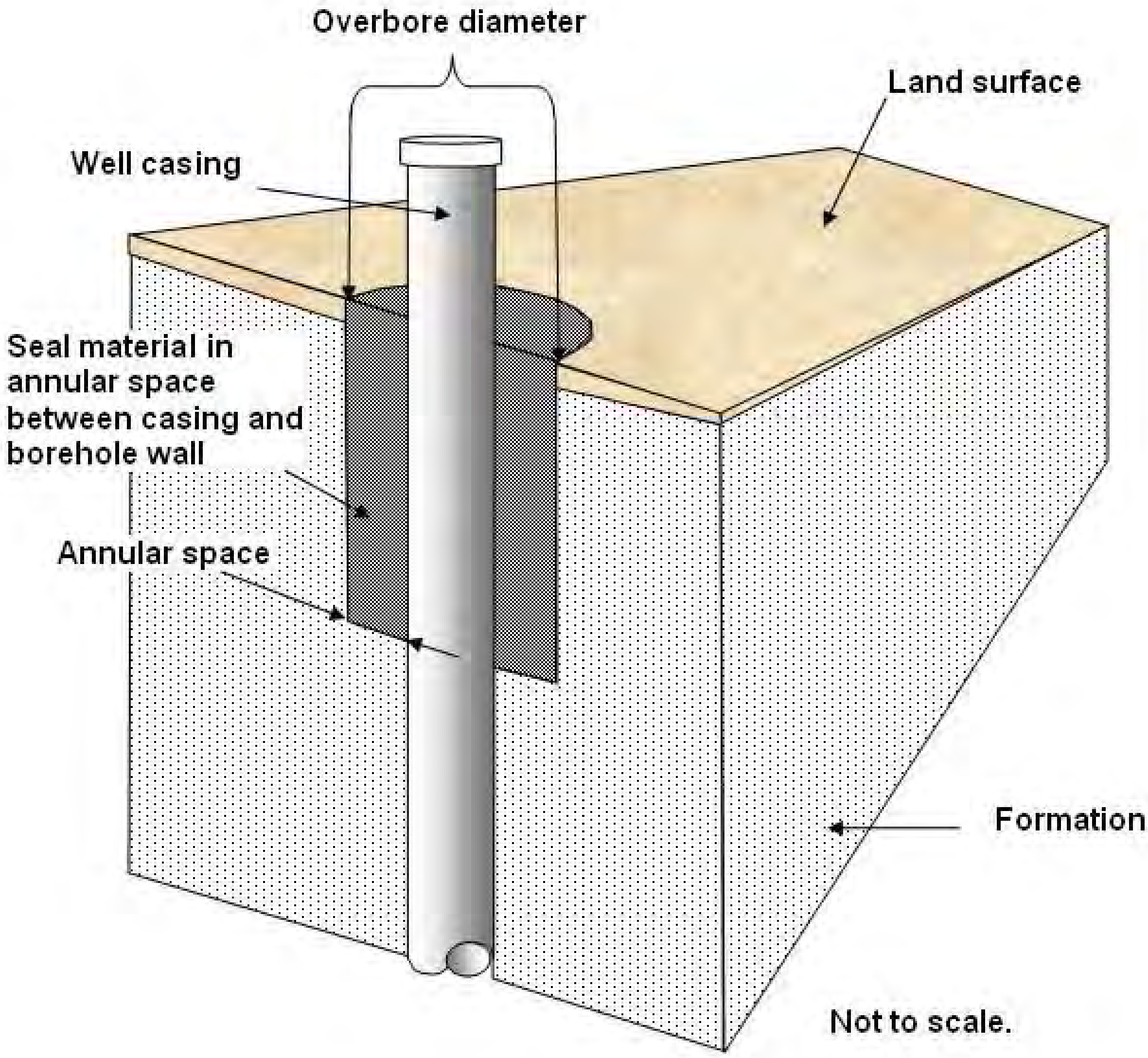


Figure 03. Overbore Requirements When a Tremie Pipe is Left in Place and A Grout Seal Installed

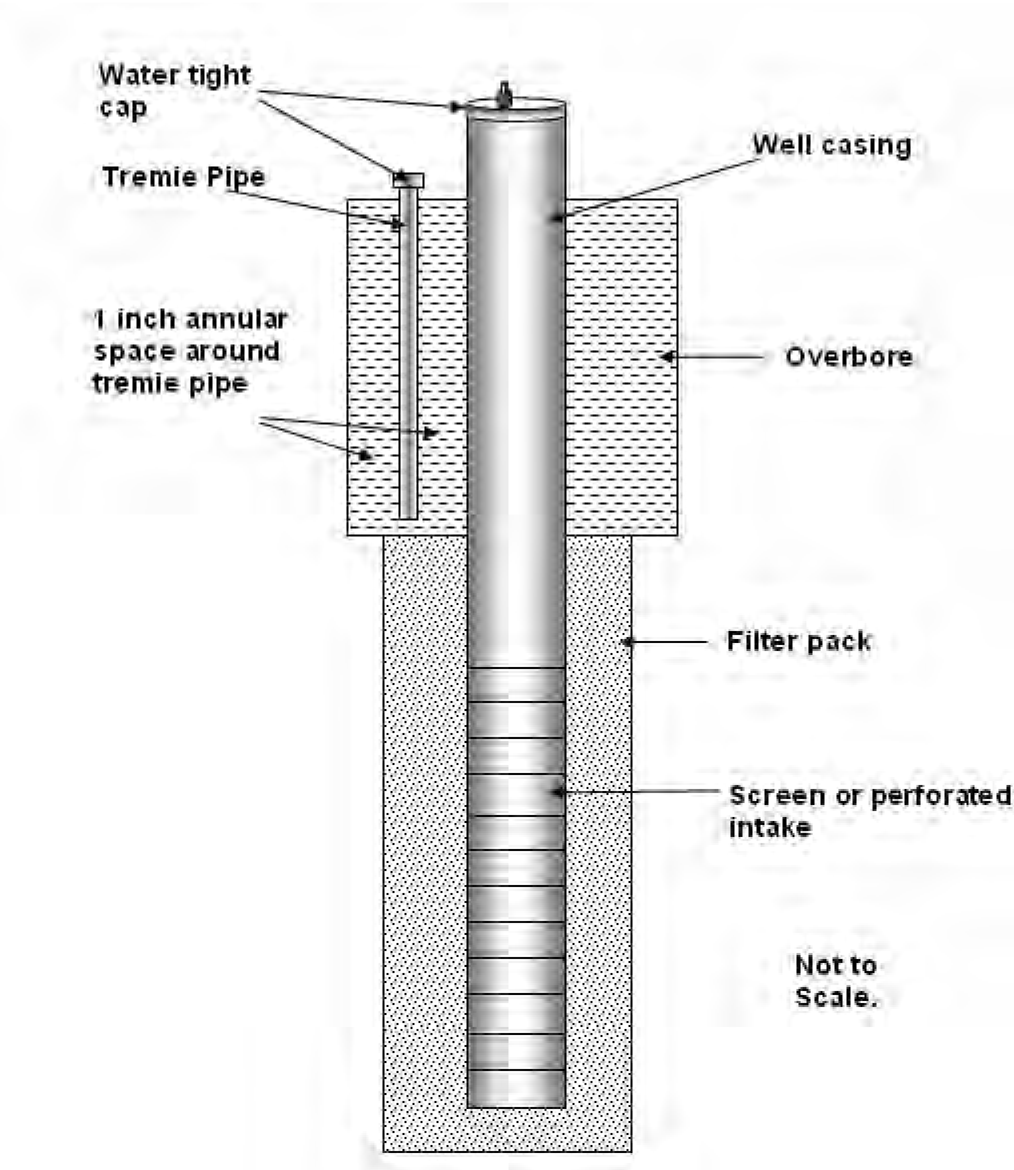


Figure 04. Sealing Requirements in Consolidated Formations

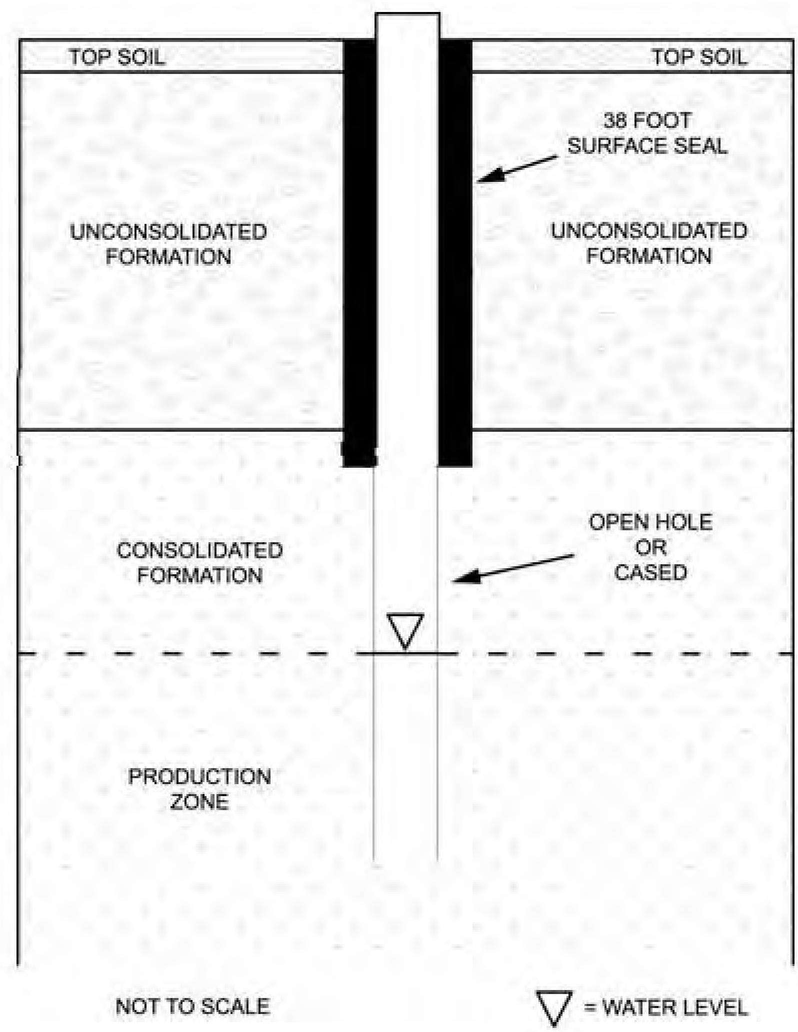


Figure 05. Sealing Requirements in Unconsolidated Formation without Confining Layers

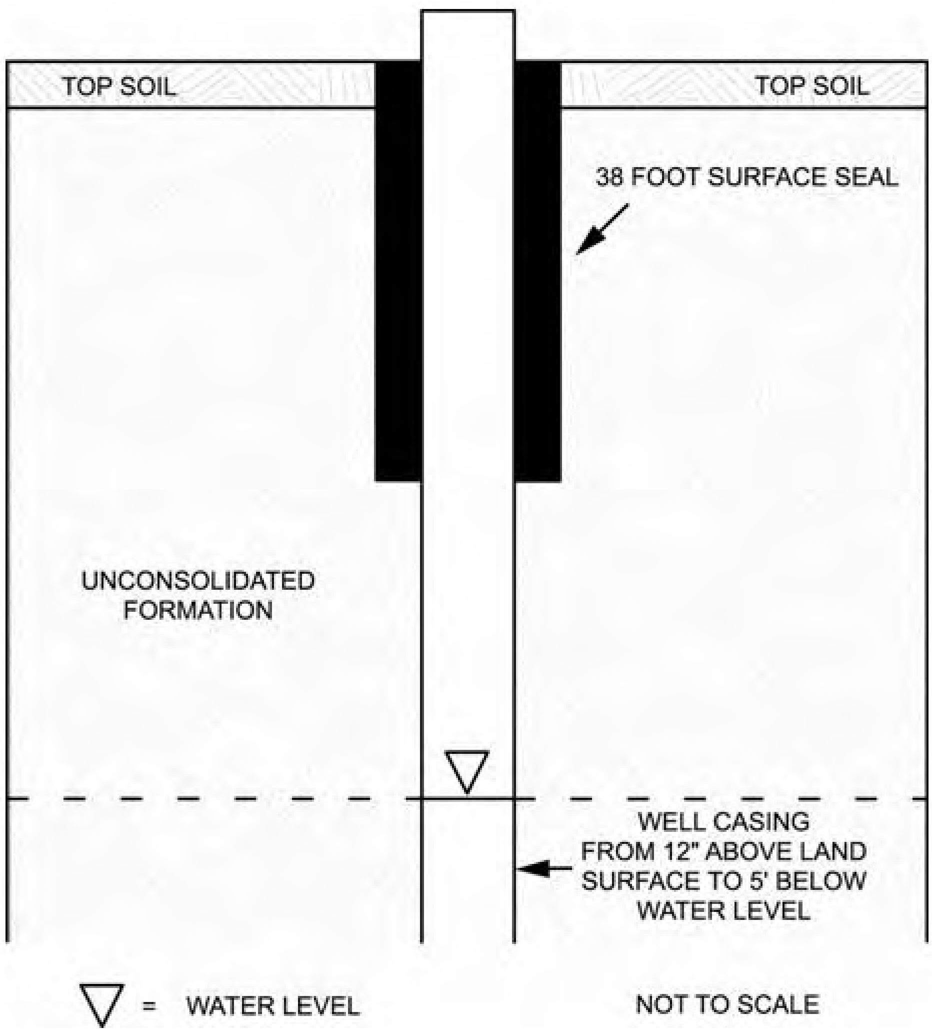


Figure 06. Rathdrum Prairie Boundary

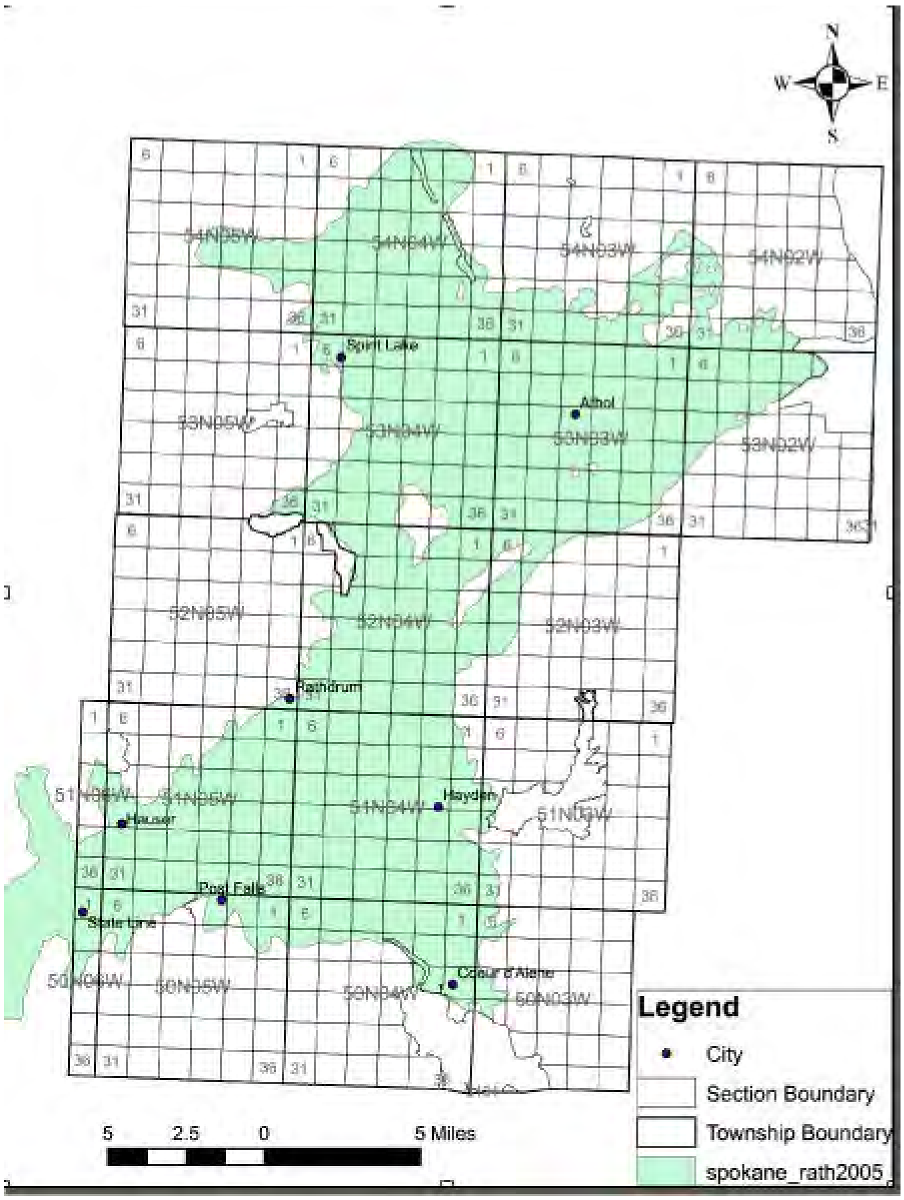


Figure 07. Sealing Requirements in the Rathdrum Prairie

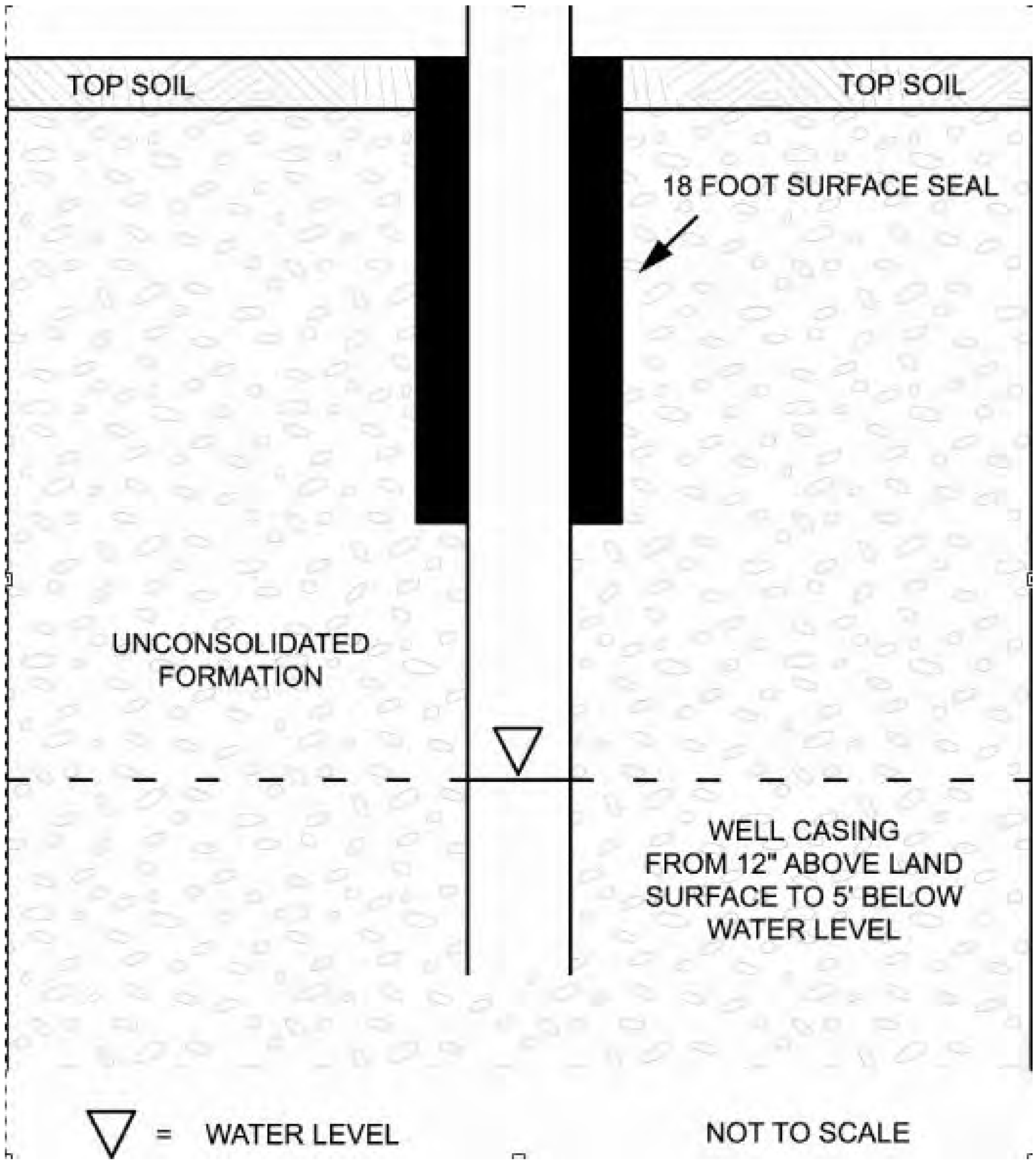


Figure 08. Sealing Requirements in Unconsolidated Formations with Confining Layers

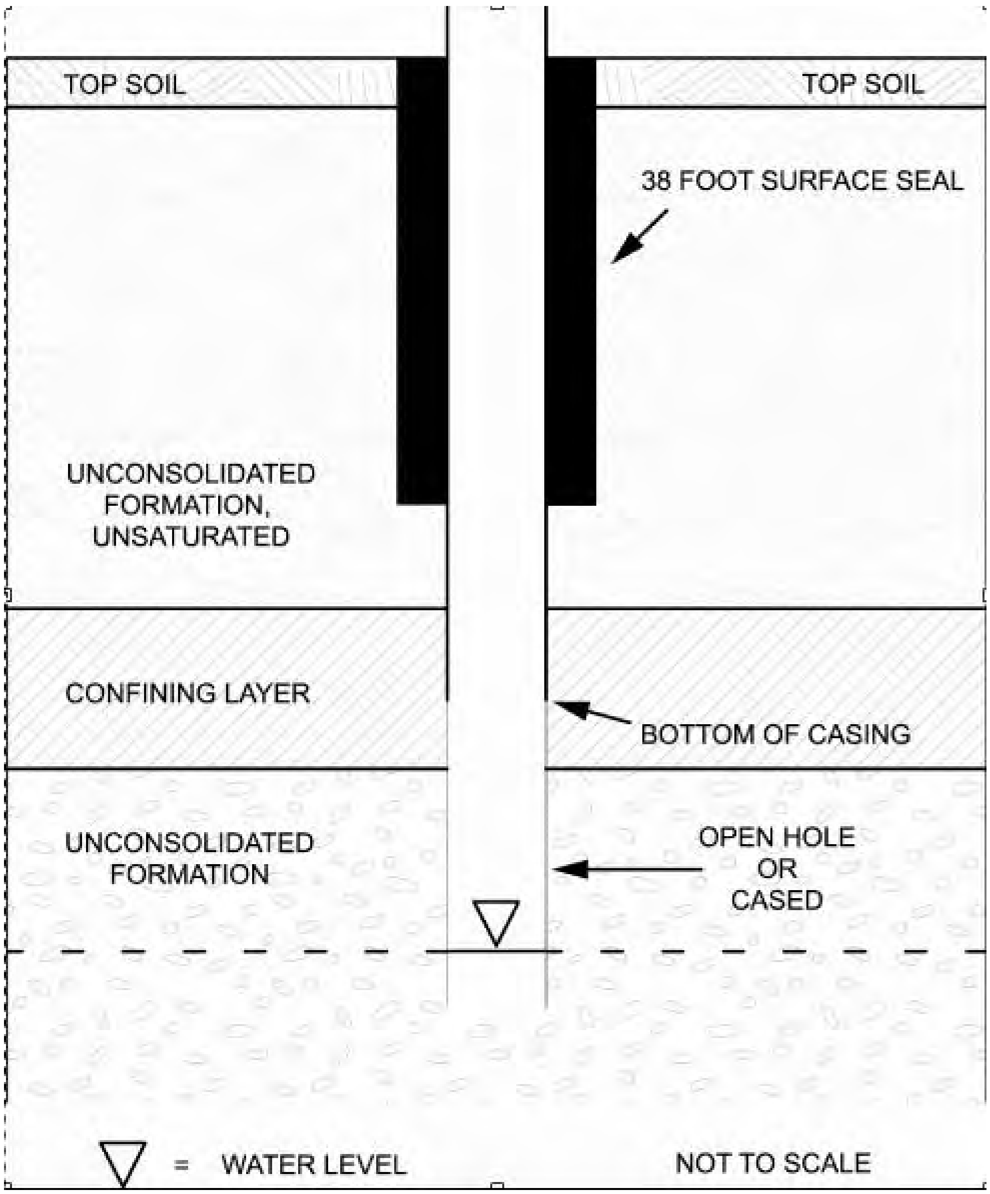


Figure 09. Sealing Requirements for Artesian Wells in Unconsolidated Formations

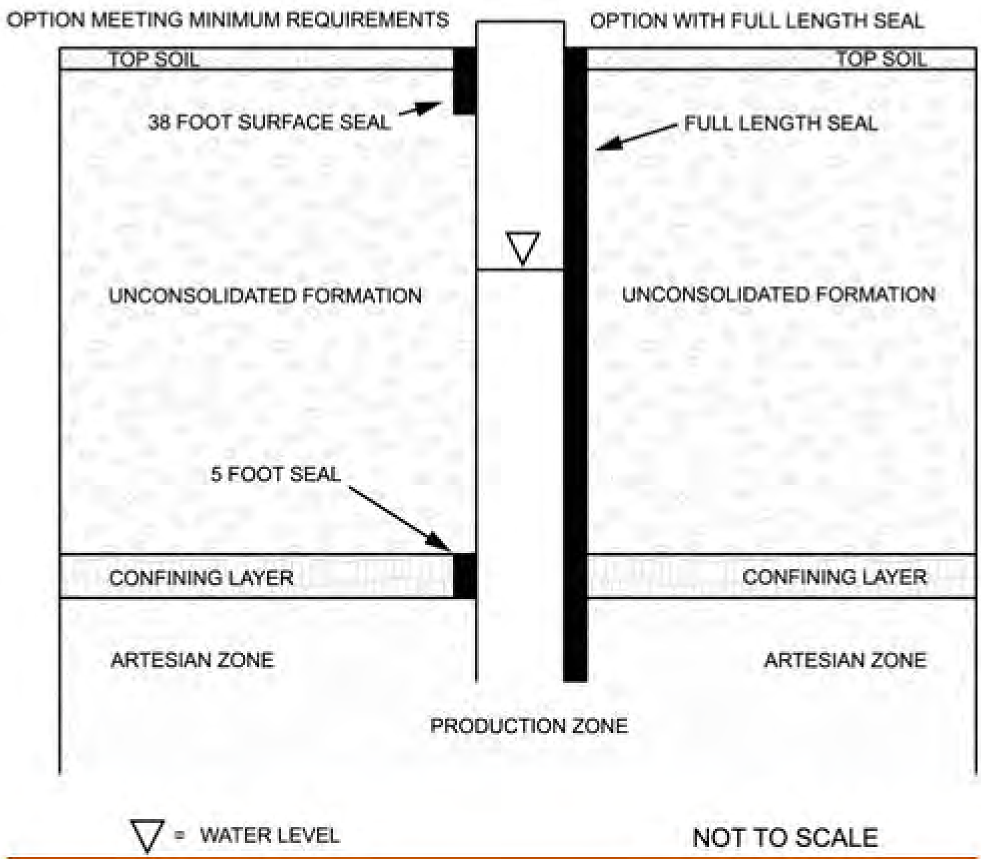


Figure 10. Sealing Requirements for Artesian Wells in Consolidated Formations

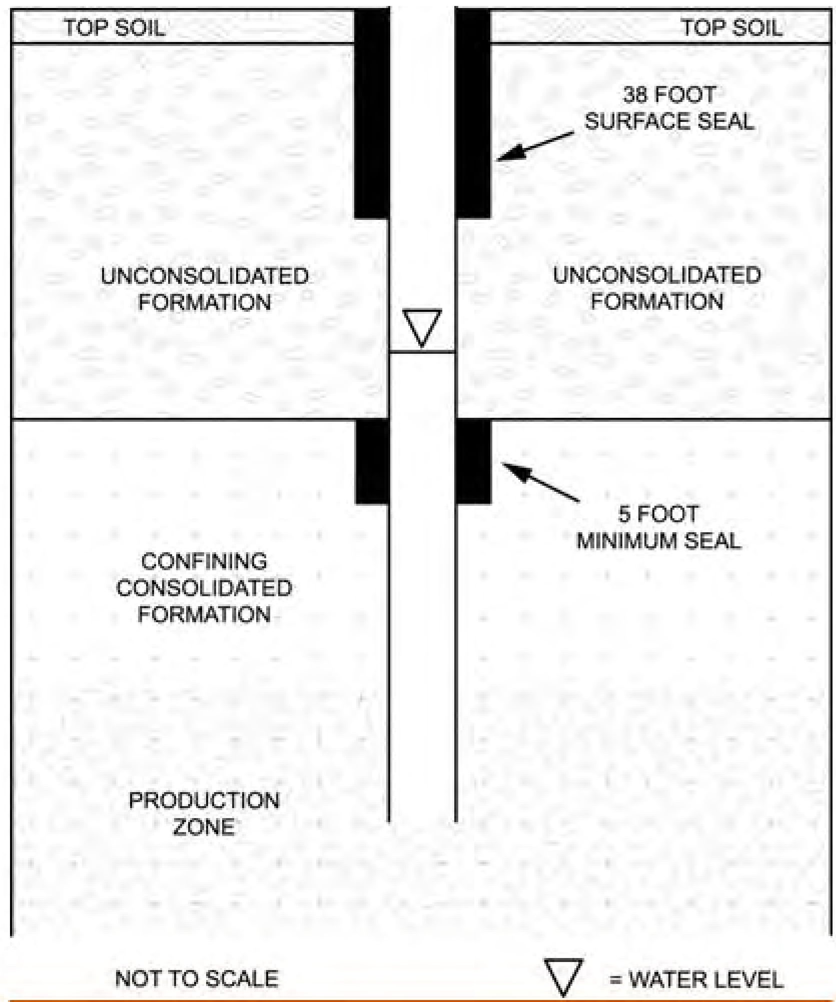


Figure 11. Access Ports, Pressure Gauges, and Control Valves

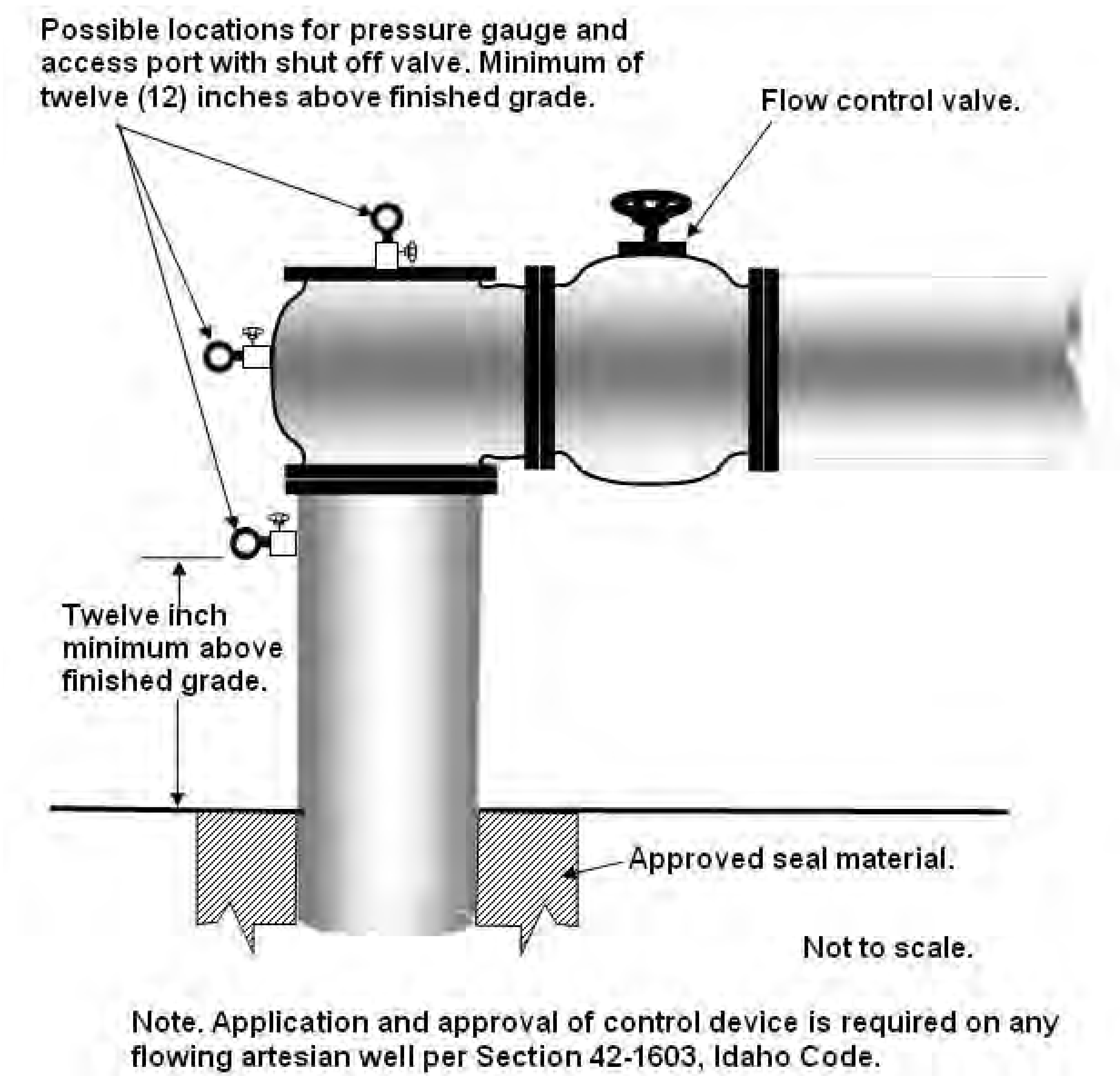


Figure 12. Well Cap and Access Port

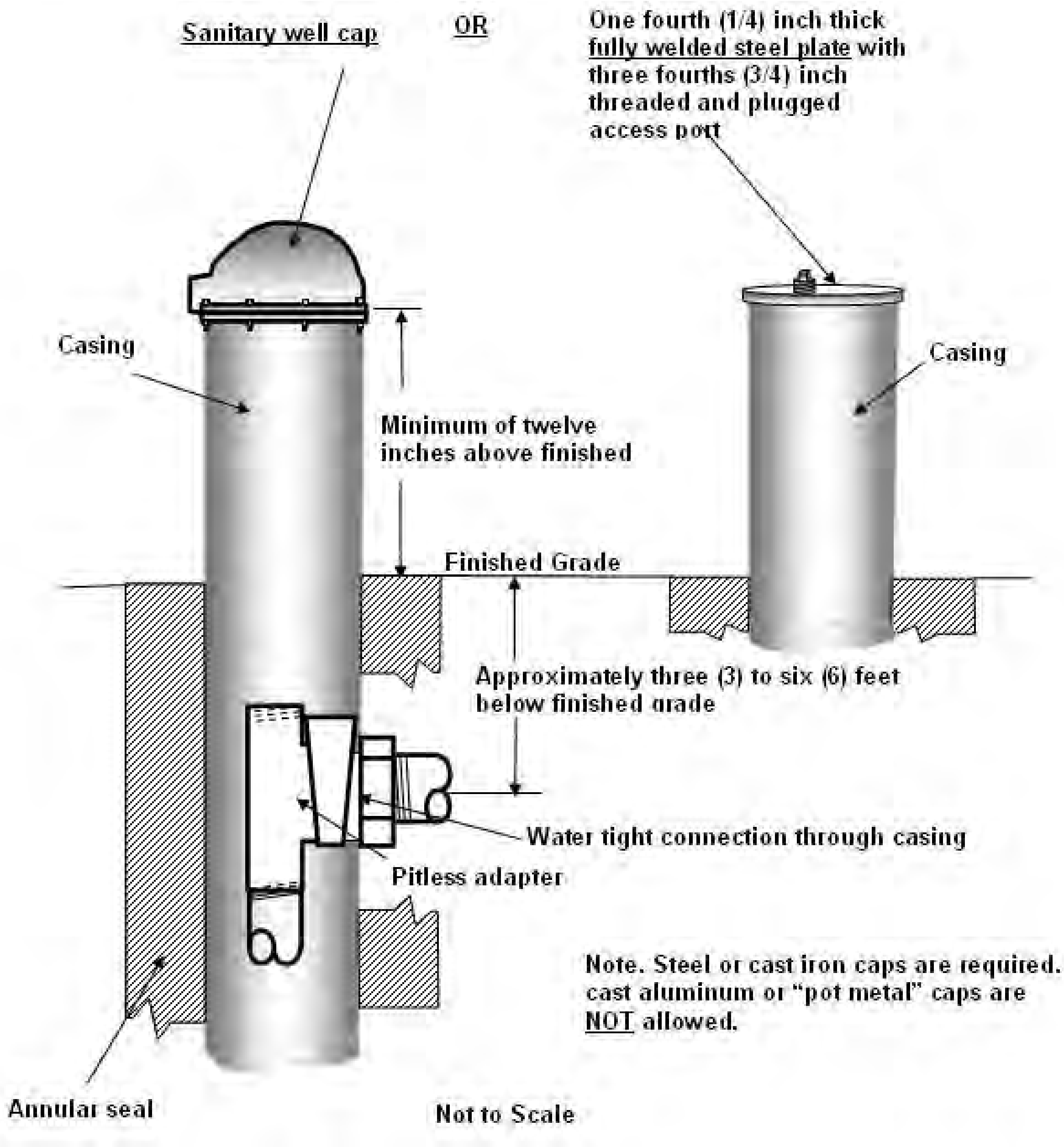
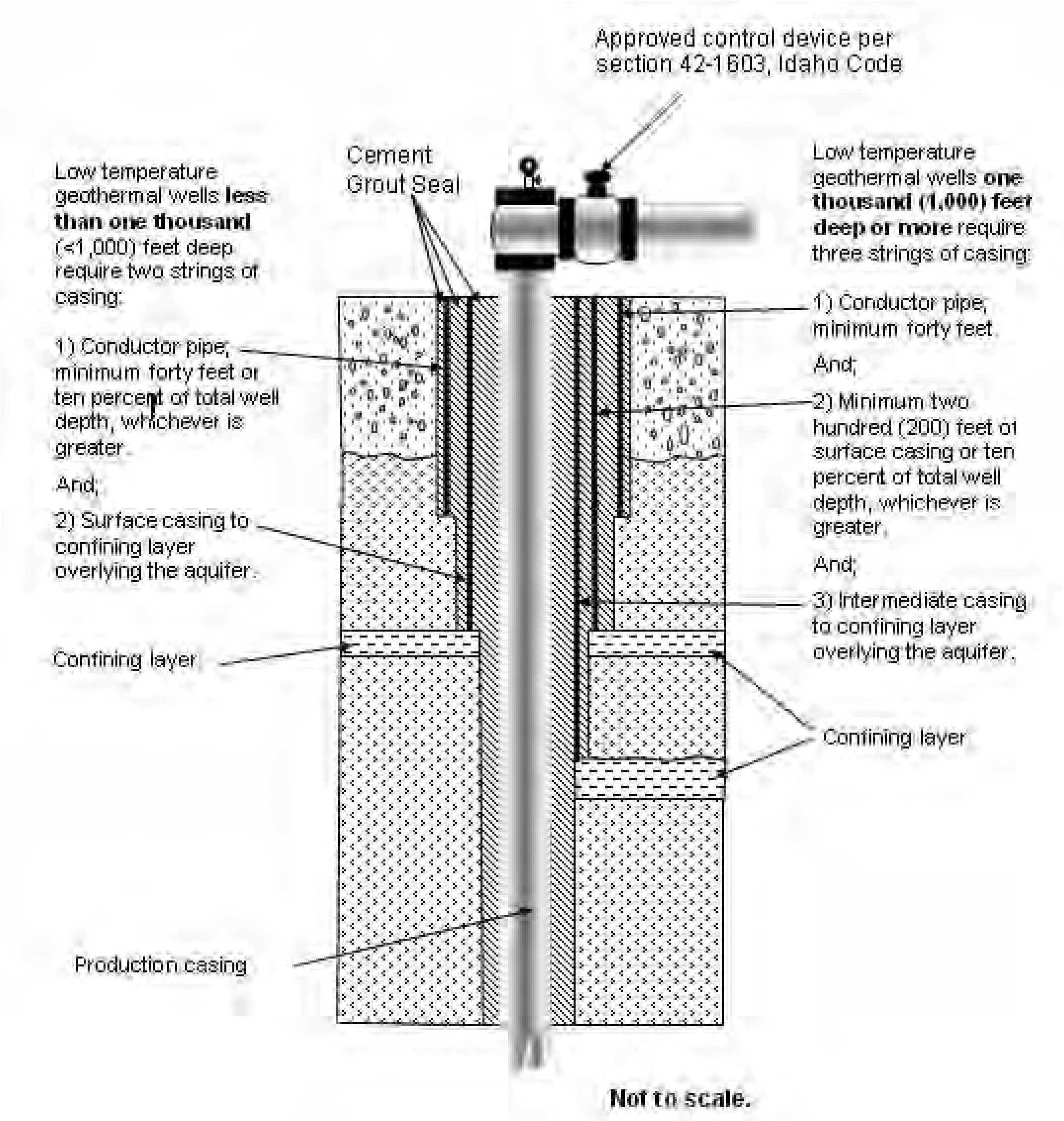


Figure 13. Casing Requirements for Low Temperature Geothermal Wells



Subject Index

APPENDIX B
TECHNICAL PROCEDURES

Golder Associates

Technical Procedure

Number: TP-1.2-3
Title: DRILLHOLE LOGGING FOR ROTARY/ CABLE TOOL DRILLING

Prepared by	Approved by	Approved by	Effective Date	Rev. Level
DP Findley 15Oct96	M.Gorman 10-16-96	[illegible] 10-16-96	10-18-96	-1-

UNCONTROLLED COPY
The hard copy of this document is not controlled and may be obsolete.
Verify current revision level prior to use.

RECORD OF REVISION
TP-1.2-3
Rev. 1

Section	Description of Revision
Throughout	Editorial changes and clarifications
8.3 & Figure 3	Changed Procedure Alteration Checklist to Field Change Request

1. PURPOSE

This procedure establishes a method, consistent with other standard Golder Associates Inc. procedures, for collection of geotechnical and hydrogeological data during rotary or cable tool drilling.

2. APPLICABILITY

This procedure applies to all Golder Associates Inc. personnel or (when invoked through procurement documentation) subcontractors assigned responsibilities for collection of data during rotary or cable tool drilling.

3. DEFINITIONS

None

4. REFERENCES

4.1 Golder Associates Inc. Technical Procedure TP-1.2-1, "Rock Core Drilling and Sampling."

4.2 Golder Associates Inc. Technical Procedure TP-1.2-2, "Geotechnical Rock Core Logging."

4.3 Golder Associates Inc. Technical Procedure TP-1.2-5, "Drilling, Sampling, and Logging of Soils."

4.4 Golder Associates Inc. Technical Procedure TP-1.2-12, "Monitoring Well Drilling and Installation."

5. DISCUSSION

This procedure addresses the collection of hydrogeological and geotechnical data during rotary or cable tool drilling. The standard Record of Drillhole form identified in technical procedure TP-1.2-2, "Geotechnical Rock Core Logging," has been modified to accommodate rotary or cable tool drilling techniques and is described in detail in this procedure. Detailed discussions regarding drilling techniques, rock core logging, and drilling and sampling of soils are located in technical procedures TP-1.2-1, "Rock Core Drilling and Sampling;" TP-1.2-2, "Geotechnical Rock Core Logging;" TP-1.2-5, "Drilling, Sampling, and Logging of Soils;" and TP-1.2-12, "Monitoring Well Drilling and Installation," which are referenced herein.

6. RESPONSIBILITIES

6.1 Project Manager

The Project Manager is responsible for overall management of the logging activities, but may delegate responsibilities to qualified Geologists/Field Engineer. The Project Manager is responsible for approving all variations from the methods established by this procedure, for preparation of the overall scope of work for the logging activity, for preparation of procurement documents for all subcontractors, and for briefing all field personnel on any requirements unique to the particular project.

6.2 Geologist/Field Engineer

The Geologist/Field Engineer is responsible for performing logging in compliance with the requirements of this procedure. The Geologist/Field Engineer is responsible for developing sufficient understanding of the ultimate goals of the investigation in order to properly record all required information and to be able to make sound decisions in the event of unforeseen situations.

7. EQUIPMENT OR MATERIALS

- Record of Drillhole forms for rotary/cable tool drilling (Figure 1)
- Water to rinse cuttings
- Hand lens
- Knife
- Screen strainer
- Field Change Request forms

8. PROCEDURE

8.1 General Information

The Golder Associates Inc. Rotary/Cable Tool Record of Drillhole form is designed specifically for use with air or mud rotary (including reverse circulation) and cable tool drill rigs. The Record of Drillhole form has been designed to facilitate collection of important hydrogeologic and geotechnical data during logging of borehole cuttings. When coring or using sampling equipment which produces intact samples, standard Golder rock coring and soil drillhole logs should be used as specified in technical procedures TP-1.2-2" Geotechnical Rock Core Logging," and TP-1.2-5, "Drilling, Sampling and Logging of Soils."

8.2 Completion of Rotary/Cable Tool Record of Drillhole Forms

An example of a Rotary/Cable Tool Record of Drillhole form used for field logging is attached as Figure 1. An example of a completed Rotary/Cable Tool Record of Drillhole form is included as Figure 2. The Rotary/Cable Tool form is comprised of header, footer, and data sections.

8.2.1 Header and Footer Sections

The header and footer sections contain relevant information about the project and drillhole.

The following data shall be specified on each Record of Drillhole form; please see the example form shown in Figure 2.

Header Section

PROJECT:	Golder Associates Inc. project short title, Owner/Project/State, e.g., ACME/MON. WELLS/WA
PROJECT NO:	Project and task number for drilling, e.g., 899-7777
LOCATION:	Project Location, e.g., Cheney, WA
DRILLING DATE:	Start and completion dates of drilling, e.g., 2 JANUARY, 1989 - 3 JANUARY 1989
DRILL RIG:	Type and model of drilling, e.g., CP 650 W.S. ROTARY
ADDITIVES:	Any drilling fluids or additives, e.g., REVERT POLYMER, None
DATUM:	Elevation datum - Mean Sea Level (MSL) or as specified.
COLLAR ELEVATION:	Surveyed elevation of collar relative to datum, if available
COORDINATES:	Surveyed northing and easting of collar, if available
AZIMUTH:	Surveyed azimuth of inclined borehole at collar (use N/A - not applicable for vertical boreholes)
INCLINATION:	Surveyed inclination from horizontal of borehole at collar or 90 for vertical drillhole.

Note: If collar elevation, coordinates, azimuth, and inclination are not surveyed, this must be noted and the method of estimating these features should be specified on the log or in accompanying notes.

Footer Section

DEPTH SCALE:	Specify the depth scale in feet per inch (or meters per cm) 1 in. = 2 ft. or 1 in. = 5 ft. are typical scales for detailed logging of cuttings samples.
DRILLING CONTRACTOR:	The name of the company conducting the drilling operations.

LOGGED:	The first initial and last name of the field geologist or engineer who logged the drillhole - do not use initials only.
CHECKED:	The first initial and last name of the individual who checked and approved the final logs.
DATE:	The date the final logs were approved.

8.2.2 Data Section

The data section in the Rotary/Cable Tool Record of Drillhole form consist of twelve columns in which to record pertinent information for hydrogeologic and geotechnical documentation.

8.2.2.1 Depth Scale

The depth Scale is used to record the drill hole depth using the scale selected and recorded in the footer section. The scale selected will depend on the stratigraphic complexity of the rock or soil and the level of detail required. A scale of 1 inch = 1 foot, will result in 8 feet of borehole to a page; a scale of 1 inch = 5 feet will result in 40 feet of borehole to a page.

8.2.2.2 Soil/Rock Type Description

The Description section allows for a complete and detailed lithologic description. The soil and rock description systems used by Golder Associates are detailed in technical procedures TP-1.2-5, "Drilling, Sampling, and Logging of Soils," and TP-1.2-2, "Geotechnical Rock Core Logging."

The soil description involves the following general format:

1. Consistency or density,
2. Color,
3. Structural characteristics,
4. Composition with major component in capital letters,
5. Minor characteristics
6. Moisture, and
7. Geologic or stratigraphic name in capital letters and parentheses.

Consistency or density when drilling with cable tool and rotary rigs can usually be estimated by factors such as the drill bit type, rate of penetration, downpressure, etc. Unless undisturbed samples can be taken, structural characteristics should not be included in sample descriptions. If drive-tubes, shelby tubes or split-spoon sampling equipment is used, structural characteristics should be included in soil descriptions. A moisture content shall be included following the description when drilling with air rotary.

Logging soil cuttings from a rotary or cable tool drill rig requires practice. A rotary drill rig will grind or pulverize the soil into a powder or mud before it is discharged from the borehole. A cable tool drill rig will also pulverize the sample during hard tool drilling. It is important to look at all materials being discharged from the borehole to determine the relative amount of fines. It is often useful to then sift the sample through a screen strainer while rinsing in water in order to determine grain size distribution and rock types. Be aware that a significant amount of fines can be lost through the screen during washing. Angularity of grains can be determined from intact faces of the gravel cuttings. Communication with the driller is especially important as he can contribute useful information on the nature and depth of the drilled formation, water table, voids, etc.

The rock description system used by Golder Associates is as follows:

"Weathered State, Structure, Color, Grain or Crystal size, Strength, ROCK TYPE"

When logging rock cuttings it is very important to observe the cuttings closely. Fractures in the rock can often be identified by oxidized surfaces. The rock type and mineral distribution can be identified with a hand lens. A knife can be used to scrape the individual cuttings to determine hardness. Rock cuttings should be rinsed with water before they are logged. Information such as cutting size and angularity should be recorded. Structure can only be estimated from the information available (e.g., 10% of particles in return have fracture faces). Strength descriptions should not be included when cable tooling and rotary drilling unless an undisturbed depth specific sample can be obtained.

8.2.2.3 Rock/Soil Type Graphic Log

The Graphic Log subsection of the Rock Type uses standard lithologic symbols to represent the rock types encountered throughout the drillhole. Contacts between the rock types are represented as follows:

Contact Type	Representation on Graphic Log
Sharp	Solid horizontal line at contact location
Gradation	Solid slanted line from start of gradational change to end of gradational change.
Inferred Contact	Dashed slanted line extending over length of inferred contact.
Erosional	Solid wavy line at contact location.
Fault	Heavy solid horizontal line at contact location.

8.2.2.4 Sample Number

Record consecutive numbers for each sample within a given drill hole, dividing samples by solid horizontal lines at the beginning and end of each sample depth. If a drive sampler is used, sample recovery shall also be included in this column.

8.2.2.5 Sample Type

Record the sample type adjacent to the sample number(s), dividing samples by solid horizontal lines at the beginning and end of each sample (e.g., grab, shelby tube, split-spoon, etc.).

8.2.2.6 Elevation/Depth

Record the depths at the beginning and end of each sample and at lithologic boundaries. Use feet and decimals (tenths) of a foot. Elevations may be filled in after survey data is available.

8.2.2.7 Total Casing Length

The Length of casing when drilling and driving casing is very important. When drilling monitoring wells or supply wells in unconsolidated material, a temporary outer casing is installed to prevent caving of the formation or to seal out formation waters. The temporary casing is pulled back to expose the well screen or removed entirely as the well is completed. It is necessary to know the exact depth of the casing in order to properly set a telescoping well screen or to prevent bridging of materials when backfilling and simultaneously removing outer casing from the borehole.

Casing measurements shall be independently verified by the Geologist/Field Engineer. The total casing length shall include the drive-shoe. Each time a new section of casing is added to the casing string, a new total length shall be written in the Casing Length column under a solid horizontal line at the current depth of the bottom of the drive shoe.

8.2.2.8 Hole Diameter/Casing Diameter/Bit Type

The hole diameter, casing diameter and drill bit type shall be recorded in this column. Any changes in hole diameter, casing or bit type shall be separated by a horizontal solid line at the depth that the change occurred.

8.2.2.9 Weathering/Alteration Index

The Weathering/Alteration Index column is used to record the weathering classification in accordance with the ISRM recommended classification system which is described in technical procedure TP-1.2-2, "Geotechnical Rock Core Logging," and demonstrated in Figure 2. Changes in the Weathering Index are indicated by a solid horizontal line at the depth of change of an abrupt change, or a solid slanting line covering the range of the weathering change.

8.2.2.10 Moisture/Water Levels/Yield (GPM)

The Moisture/Water Levels/Yield column is used during drilling to record changes in the moisture content of the drill cuttings and to record changes in yield after the water table has been reached. Changes in moisture content shall be separated by a horizontal solid line at the depth that the changes took place. Moisture and water levels should be checked regularly during drilling. When drilling with air and fluids it is often difficult to determine when the water table is reached. The drilling air often dries out the drill cuttings as they are blown out of the drillhole. When drilling with fluids and additives, it is often difficult to determine when the fluid discharge increases and the water table has been penetrated. To avoid missing important water bearing zones, water levels should be checked frequently. Water levels can be checked during shut downs by lowering a water level indicator through the drill rods to the bottom of the borehole. Water levels shall be measured at the beginning and end of each shift. Yield can be measured by raising the drill bit 1-2 feet off the bottom of the drillhole and air lift pumping water into a five gallon bucket. Monitoring the drill fluid level in the settling tank or pit can provide information of drillhole intervals that may be producing groundwater or losing drill fluid to the formation. Any time a water level is taken or the yield is measured, the instruments and method shall be documented in the notes column of the drillhole log.

8.2.2.11 Time/Rate of Advance

The Time/Rate of Advance column serves several purposes. The time shall be recorded regularly during drilling and each time the driller starts and stops drilling. Any shutdowns, welding time, problems, etc. should be recorded in the time column. The time is entered at the depth that the particular event occurred on the drillhole log. Always record events in military or 24 hour time format; e.g., 1 PM should be recorded as 1300. From the Time/Rate of Advance column, the rate of advance can be calculated for any specific depth and any problems or shutdowns may be referenced to the History of Hole form for explanation. The History of Hole form is discussed in TP-1.2-5, "Drilling, Sampling, and Logging of Soils," and is used to record events associated with the drilling of each hole.

8.2.2.12 Notes, Drilling Method, Instrumentation

The Notes, Drilling Method, Instrumentation column shall be used to record any information that affects the drilling of the borehole, the quality of the samples, delays shutdowns, standby and any information that might be misinterpreted from the rest of the drillhole log. Detailed explanations may be referenced to the History of Hole form. Any water or additives should be documented in the notes column. The manufacturer, common name, and quantity of all materials added to the borehole shall be documented.

8.3 Field Change Request

Variations from established procedure requirements may be necessary due to unusual field situations or unique client requirements. The Project Manager may delegate authority to the onsite Geologist/Field Engineer to initiate variations as necessary to respond to such situations; however, all variations from established procedures shall be documented on Field Change Request form (Figure 3) and verbally reported to the Project Manager within 24 hours. The Field Change Request shall be submitted to the Project Manager and the QA Manager for formal review and approval within 2 working days. Disapproval of a Field Change Request shall require re-performance of the logging activity or other appropriate resolution as directed by the Project Manager.

tp1'2-3.rv1

RECORD OF DRILLHOLE (ROTARY/CABLE TOOL)

Sheet of

PROJECT:
PROJECT NO:
LOCATION:

DRILLING DATE:
DRILL RIG:
ADDITIVES:

DATUM:
COORDINATES N:
AZIMUTH:

COLLAR ELEV:
E:
INCLINATION:

DEPTH SCALE (FEET)	DESCRIPTION	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	(ELEVATION) DEPTH	TOTAL CASING LENGTH	HOLE DIAMETER/ CASING DIAMETER/ BIT TYPE	WEATHERING INDEX	MOISTURE WATER LEVELS YIELD (GPM)	TIME/ RATE OF ADVANCE	NOTES DRILLING METHOD INSTRUMENTATION

SCALE:
DRILLING CONTRACTOR:
DRILLER:

LOGGED:
CHECKED:
DATE:

Golder Associates

FIGURE 1
RECORD OF DRILLHOLE FORM (ROTARY/CABLE TOOL)
TP-1.2-3

PROJECT NO. IP3 1024.200 DRAWING NO. 68272 DATE 10/14/96 DRAWN BY EA

Golder Associates

RECORD OF DRILLHOLE DNAPL-1
(ROTARY/CABLE TOOL)

PROJECT: ACME/MON.WELLS/WA
PROJECT NO: 899-7333.444
LOCATION: CHENEY, WA

DRILLING DATE: 2 JANUARY, 1990
DRILL RIG: CP 650 W.S. ROTARY
ADDITIVES: NONE

DATUM: MSL
COORDINATES N: 68345
AZIMUTH: NA

COLLAR ELEV: NA
E: 23112
INCLINATION: 90°

DEPTH SCALE (FEET)	DESCRIPTION	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	(ELEVATION) DEPTH	TOTAL CASING LENGTH	HOLE DIAMETER/ CASING DIAMETER/ BIT TYPE	WEATHERING INDEX	MOISTURE WATER LEVELS YIELD (GPM)	TIME/ RATE OF ADVANCE	NOTES DRILLING METHOD INSTRUMENTATION
0	0.0-2.0 - COMPACT, MODERATE BROWN (5YR 4/2), FINE TO MEDIUM SAND, SOME GRAVEL, TRACE SILT, ABUNDANT ROOTS, MOIST (TOPSOIL)		1	GRAB SAMPLES (0.0-31.0)			10-INC DIA. STEEL CASING; 10-INC DIA. TRI-CONE BIT (0.0-18.0)	NA	MOIST	0830	STARTED DRILLING AND DRIVING 10-INCH DIA. STEEL CASING WITH 10-INCH TRICONE BIT. AIR CIRCULATION DRILLING WITH CASING HAMMER. GRAB SAMPLING HOLDING BACK DRILL BIT.
	2.0-31.0 - DENSE, MODERATE BROWN (5YR 4/2), SILTY SAND AND GRAVEL, TRACE CLAY, GRAVELS ARE SUBANGULAR, MOSTLY BASALT, DAMP (GLACIAL TILL)		2		2.0				DAMP		
5			3		5.0					0850	
10			4		10.0					0910	
										0915 0930	DOWN BROKEN HOSE, SEE HISTORY-OF-HOLE (HOH)
15			5		15.0	20.0 +10.2				0945	
					18.0	30.2				1000 1115	10-INCH DIA. CASING TO 18.0 FEET. SWITCHED TO 6-INCH TRI-CONE BIT.
20			6		20.0		6-INC DIA. STEEL CASING W/DRIVE SHOE (18.0-33.0); 6-INC DIA. TRI-CONE BIT (18.0-40.0)			1120	6-ICH CASING TELESCOPED TO 18.0 FEET. WELDED ON 10.2 FOOT SECTION OF 6-INCH DIA. STEEL CASING. DRILL AND DRIVE 6-INCH DIA. STEEL CASING FROM 18.0 FEET.
25			7		25.0	30.2 +10.0				1130	
					27.0	40.2			NO WATER	1135 1220	WELDED CASING, CHECKED FOR WATER IN BOTTOM OF BOREHOLE WITH WATER LEVEL INDICATOR AFTER 30 MIN SHUTDOWN.
30										1225	
	31.0-33.0 - SOFT, DUSKY YELLOWISH BROWN (10YR 2/2), CLAY, MOIST		8	SH	31.0	40.2 -4.2			MOIST	1227 240	SHUTDOWN IN CLAY, TRIPPED OUT, SAMPLED WITH SHELBY TUBE. SEE HOH
	33.0-40.0 - MODERATELY WEATHERED, HIGHLY FRACTURED, DUSKY YELLOWISH BROWN (10YR 2/2), APHANITIC, VESICULAR, WEAK, BASALT, DAMP - FRACTURE SURFACES FeOx STAINED - RARE CLAY COATINGS ON FRACTURE SURFACES - 35.0-36.0 - VOID IN ROCK			GRAB (33.0-40.0)	33.0	36.0		W3	DAMP	1300 1320	CUT CASING, CHECKED BOREHOLE FOR WATER - NONE, DRILLING OPEN HOLE FROM 33.0 FEET.
35										1325	35.0-36.0 - VERY FAST DRILLING, NO RECOVERY, VOID IN ROCK
										1325	
			9								3000 PSI DOWN PRESSURE.
40										1410	

SCALE: 1 INCH = 5 FEET
DRILLING CONTRACTOR: KELLY BROTHERS
DRILLER: BOB KELLY

LOGGED: J. GEOHEAD
CHECKED:
DATE:

Golder Associates

FIGURE 2
EXAMPLE RECORD OF DRILLHOLE (ROTARY/CABLE TOOL)

RECORD OF DRILLHOLE DNAPL-1 (ROTARY/CABLE TOOL)

PROJECT: ACME/MON.WELLS/WA
PROJECT NO: 899-7333.444
LOCATION: CHENEY, WA

DRILLING DATE: 2 JANUARY, 1990
DRILL RIG: CP 650 W.S. ROTARY
ADDITIVES: NONE

DATUM:
COORDINATES N: 68345
AZIMUTH: NA

COLLAR ELEV: NA
E: 23112
INCLINATION: 90°

DEPTH SCALE (FEET)	DESCRIPTION	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	(ELEVATION) DEPTH	TOTAL CASING LENGTH	HOLE DIAMETER/ CASING DIAMETER/ BIT TYPE	WEATHERING INDEX	MOISTURE WATER LEVELS YIELD (GPM)	TIME/ RATE OF ADVANCE	NOTES DRILLING METHOD INSTRUMENTATION
40	40.0-61.0 - FRESH, APHANITIC, MEDIUM DARK GRAY (N4), (BASALT), DRY			GRAB SAMPLES FROM CYCLONE		36.0	6-INCH TRI-CONE BIT	W1	DRY	1410	10,000 PSI DOWNPRESSURE
			10		42.5		6-INCH DIA. DOWN-THE-HOLE HAMMER DRILL BIT			1415 1435	SWITCHED TO DOWN-THE-HOLE HAMMER BIT
45			11		45.0				STARTED MISTING DAMP CUTTINGS	1440 1445	STARTED DRILLING WITH LIGHT MIST (14 GAL/MIN) BECAUSE OF SURFACE DUST PROBLEMS. WATER FROM CHENEY CITY WATER.
50			12		50.0					1455	
	54.0-54.5 - FRACTURES IN ROCK, DARK REDDISH BROWN (10YR 3/4), COATED CUTTINGS AND FRACTURE SURFACES.										
55			13		55.0					1510	
60					60.0				MOIST TO WET	1525	MOISTURE INCREASES - SHUT OFF MIST
	61.0-71.0 - MODERATELY WEATHERED, HIGHLY FRACTURED, APHANITIC, VESICULAR, DUSKY YELLOWISH		14					W3	WET - 1/4 GPM	1530 1610	SHUTDOWN TO CHECK FOR WATER S.W.L. AT 59.3 FEET BELOW SURFACE AFTER 35 MINUTES. SEE HOH. STARTED DRILLING. WATER DISCHARGING FROM CYCLONE (~1/4 GAL/MIN). YIELD INCREASES DOWNWARD DURING DRILLING.
65			15		65.0					1625	
70					70.0				3.7 GPM 57.0 SWL	1635 1710	SHUTDOWN, CHECKED STATIC AFTER 15 MINUTES - 57.0 FEET BELOW SURFACE. AIR LIFT PUMPED WATER FOR 5 MIN. AT ~3 GPM. 3 MIN. RECOVERY TO 57.0 FEET. YIELD STARTED DECREASING AT 71.0 FEET.
	71.0-75.0 - FRESH, APHANITIC, MEDIUM DARK GRAY (N4), MEDIUM STRONG, (BASALT)		16					W1	DECR. YIELD		
75	75.0 FEET TOTAL DEPTH								1.5 GPM	1730	TERMINATED DRILLING, STARTED WELL DEVELOPMENT BY AIR LIFTING WATER. SEE HOH.
80											

SCALE: 1 INCH = 5 FEET
DRILLING CONTRACTOR: KELLY BROTHERS
DRILLER: BOB KELLY

LOGGED: J. GEOHEAD
CHECKED:
DATE:

Golder Associates

FIGURE 2 (cont)
EXAMPLE RECORD OF DRILLHOLE (ROTARY/CABLE TOOL)

FIELD CHANGE REQUEST

Golder Associates

Job/Task Number: ______________________________

Other Affected Documents: ______________________________

Requested Change: ______________________________

Reason for Change: ______________________________

Change Requested by: ______________________ Date __________

Reviewed by: ______________________ Date __________
GAI Project Manager

Comments: ______________________________

Reviewed by: ______________________ Date __________
GAI QA Manager

Comments: ______________________________

FIGURE **3**
FIELD CHANGE REQUEST FORM
TP-1.2-3

Golder Associates

Technical Procedure

Number: TP-1.2-5
Title: DRILLING, SAMPLING, AND LOGGING OF SOILS

Prepared by	Approved by	Approved by	Effective Date	Rev. Level
[signature] 4/25/96	[signature] 5/13/96	[signature] 5-15-96	5-22-96	-9-
	CURRENTLY IN	REVIEW		-10-

UNCONTROLLED COPY
The hard copy of this document is not controlled and may be obsolete.
Verify current revision level prior to use.

RECORD OF REVISIONS

TP-1.2-5
Revision Level -9-

Section	Description of Revision
Throughout	Editorial and format change throughout
3.2	Added more detail
7.2	Included more equipment
8.1.3	Added History of Hole to document Daily Site Activities
	Added note regarding the Sample Integrity Data Sheet
5 & 8.3.4	Changed storing requirements for environmental samples to 4°C $\pm$ 2°C
8.2.6 & Exhibit F	Changed Procedure Alteration Checklist to Field Change Request
Exhibit B	Edited Record of Borehole form

1. PURPOSE

The purpose of this technical procedure is to establish uniform and consistent methods for drilling, sampling, and logging soils. This technical procedure also establishes a uniform methodology for collecting representative soil samples for chemical analysis.

2. APPLICABILITY

This technical procedure is applicable to all Golder Associates Inc. representatives engaged in subsurface soils investigations. It may be used at either uncontaminated or contaminated sites. This procedure includes, as an option, the use of inner barrel liners.

3. DEFINITIONS

3.1 Breaking Drill Rod

Breaking drill rod is defined as withdrawing and decoupling drill rod in order to advance the boring, retrieve samples, or abandon the hole.

3.2 Down Time

Down time is defined as non-productive time on the part of the drilling contractor or their subcontractors related to scheduling, breakdown or other operational delays.

3.3 Contaminated Site

A contaminated site is defined as a location at which an environmental investigation is being conducted for the purpose of determining the existence or extent of hazardous waste/substances or groundwater contamination.

3.4 Inner Barrel Liner

An inner barrel liner is defined as an insert installed in the sampling tool to contain soil materials. Depending on the sampling method, the liner is generally made of Lexan, a fiber/composite material, or brass or stainless steel tubing, and is designed to fit snugly inside the sampling tool.

3.5 In Situ Soil Sample

An in situ soil sample is a (theoretically) undisturbed sample which is representative of the soil as it exists in the ground. Although all samples are disturbed to a certain extent, in situ sampling methods attempt to minimize disturbance.

3.6 Engineering/Geologic Soil Sample

An engineering/geologic soil sample is defined as soil acquired from a borehole for geotechnical or geological analysis or interpretation.

3.7 Environmental Soil Sample

An environmental soil sample is defined as soil acquired from a borehole for chemical analysis that is representative of the soil as it exists in the ground.

3.8 Sample Containers

Sample containers are specifically designed and prepared for storing soil samples. For environmental samples, sample bottle type, material, size, preservation requirements and type of lid are specific for particular tests or groups of analytes; such containers must be properly cleaned and prepared by a laboratory or the manufacturer in compliance with Reference 4.7.

3.9 In Situ Soil Testing

In situ soil testing is performed on the soil at its naturally existing location or interval; examples include cone penetrometer, standard penetration, and in situ vane shear testing.

3.10 Production Time

Production time is defined as the time spent performing contractually required activities under the drilling contract other than drilling. An example might be the time spent installing piezometers.

3.11 Stand-by Time

Stand-by time is defined as non-productive time due to the Golder Associates Geologist/Field Engineer halting work.

3.12 Subcoring

Subcoring is defined as the collection of a core from within a core. Subcoring is used to help minimize borehole cross-contamination of sample material.

3.13 Subsurface Investigation

A subsurface investigation is defined as the exploration of the soil stratigraphy, groundwater and other characteristics below the earth's surface; investigative techniques typically include drilling and sampling and excavation of test pits; (separately addressed in TP-1.2-21, "Test Pit Logging and Sampling").

4. REFERENCES

4.1 Golder Associates Technical Procedure TP-1.2-21, "Test Pit Logging and Sampling"

4.2 Golder Associates Technical Procedure TP-1.2-6, "Field Identification of Soils"

4.3 Golder Associates Technical Procedure TP-1.2-23, "Chain of Custody"

4.4 ASTM-D-1586, "Penetration Test and Split-Barrel Sampling of Soils"

4.5 ASTM-D-1587, "Standard Practice for Thin-Walled Tube Sampling of Soils"

4.6 ASTM-D-3550, "Ring-Lined Barrel Sampling of Soils"

4.7 USEPA, 1986, Test Methods for Evaluating Solid Waste (SW-846), US EPA/Office of Solid Waste, Washington, D.C.

4.8 USEPA, 1989, Soil Sampling Quality Assurance User's Guide, 2nd Edition, USEPA/Environmental Monitoring Systems Laboratory, Las Vegas, NV.

5. DISCUSSION

The purpose of any drilling and sampling program is to obtain information which will be used in evaluation of the characteristics and conditions of a particular site. The quality of any design or assessment hinges on the quality of the samples obtained and the data derived from them. Specified guidelines and procedures for drilling operations, sampling, and logging must be followed in order to obtain relatively undisturbed, uncontaminated, or otherwise uniformly useful samples. It is the Project Manager's responsibility to design the drilling and sampling program for the project, and to select the drilling and sampling techniques to be used for achieving project objectives. Standard drilling techniques are included in Appendix A, and sampling techniques in Appendix B. It is the Geologist/Field Engineer's responsibility to see that samples are obtained in compliance with the defined methods, and that accurate and complete drilling data is recorded. Drilling data should include the soil types and conditions encountered during drilling, and any variations from prescribed drilling and sampling standards. All variations must be documented on Field Change Request (Exhibit F) and approved by the Project Manager and Quality Assurance (QA) Manager. Standard forms used for recording drilling and sampling information are the History of Hole form (Exhibit A) and the Record of Borehole log (Exhibit B). Samples shall be labeled, stored and transported as appropriate for the sample type and subsequent testing or analysis.

For the collection of environmental soil samples, all sampling equipment shall be decontaminated before and after each use. If directed by the Project Manager or as specified in project work documents, soil and decontamination fluids shall be captured and contained for disposal. Samples shall be collected in properly prepared containers of the appropriate size and type. All samples shall be appropriately labelled and sealed (see Exhibit E). Environmental samples shall be stored and transported in coolers at 4°C $\pm$ 2°C. Chain of Custody (Exhibit D) shall be maintained in accordance with procedure TP-1.2-23, "Chain of Custody." The History of Hole form (Exhibit A) and Sample Integrity Data Sheet (see Exhibit C) shall be used to document daily site activities and sample collection unless alternate methods are specified by the client and/or approved work plan. All variations from established procedure shall be documented on the Field Change Request (see Exhibit F) and shall be approved by the QA Manager and the Project Manager.

Field personnel must understand the purpose and goals of their efforts in order to make appropriate judgment calls. It is the responsibility of the Project Manager to make this information available to the Geologist/Field Engineer, just as it is the responsibility of the Geologist/Field Engineer to make every effort to fully understand the purpose of the task.

6. RESPONSIBILITIES

6.1 Project Manager

The Project Manager is responsible for the overall management of the drilling and sampling project, but may delegate responsibilities to other qualified team members. Duties include design of the drilling and sampling program, location of boreholes, establishing minimum sampling frequency and sampling techniques, approving all variations from established procedures, ensuring that contractual agreements are established with the contractors, preparing the scope of work, and briefing all field personnel on the expectations and requirements peculiar to the project. The Project Manger may assume the responsibilities of the Task Leader on small projects.

6.2 Task Leader

The Task Leader is responsible for supervising the Geologist/Field Engineer. Supervision includes ensuring that samples are collected, documented, logged, handled and shipped to the appropriate laboratory as specified in project work documents and this technical procedure.

6.3 Geologist/Field Engineer

The Geologist/Field Engineer is responsible for documenting all on-site geotechnical activity. These activities include: ensuring that samples of adequate quality are obtained in a manner consistent with this procedure, documenting variations from standard procedures, logging samples, ensuring sample integrity in storage and transportation to the laboratory for testing, and reviewing the daily drilling report with the drilling contractor. The Geologist/Field Engineer shall develop an understanding of the ultimate goal of the investigation in order to adequately record needed information and be able to make sound decisions in case of unforeseen circumstances.

6.4 Document Custodian

The document custodian is responsible for maintaining project files and filing project documents, project correspondence, sample integrity data sheets, chain of custody forms, field report forms, other forms, generated data and other associated and pertinent project information.

6.5 Quality Assurance Manager

The QA Manager is responsible for approving Field Change Requests.

7. EQUIPMENT OR MATERIALS

7.1 Contractor-Supplied Equipment

The following equipment is typically supplied by the drilling contractor; actual requirements shall be as specified in the scope of work established by the Project Manager.

- Drill rig and all drilling tools, rods, bits, water tank, and related equipment.
- Sampling tools, such as split-tube samplers and bailers.
- Portable steam cleaners for cleaning environmental sampling equipment, the drilling and other drilling equipment are generally required in investigations of potentially contaminated sites, and may be provided by the drilling contractor or rented separately.
- Container(s), or 55-gallon steel drums, as required for containing drill soil cuttings and decontamination fluids.
- Shelby tubes and caps.

7.2 Golder Associates Supplied Equipment

7.2.1 General Field Supplies

Supplies required for Golder Associates field personnel generally include the following:

- Technical Procedures Field Book
- Health and Safety Plan
- Knife or spatula
- Indelible ink pens and felt tip markers
- Shipping containers
- Field Change Request Forms (Exhibit F)

- History of Hole Forms (Exhibit A)
- Camera & Film
- Sounding tape with weight
- Water level indicator
- Record of Borehole Logs (Exhibit B)
- Sample jars or bags
- Sample labels (Exhibit E)
- Folding rule
- Clipboard
- Engineering tape measure
- Flagging
- Aluminum foil teflon sheeting, plastic tube end caps, tape, seals, and paraffin or micro-crystalline wax for sample sealing purposes
- Golder staff telephone list
- Other items as dictated by project need

7.2.2 Health and Safety Equipment

Supplies for health and safety equipment generally include the following:

- Hard hat
- Hearing protection
- Sturdy boots
- Gloves
- Eye protection
- Reflective vest (road work)

7.2.3 Field Supplies for Environmental Sampling

Additional items needed for acquiring environmental soil samples at a potentially contaminated site shall be as specified by the Project Manager and/or site health and safety plans, and may include the following:

- Site Sampling Plan, Work Plan, QA Plan and/or Health and Safety Plan (HASP)
- Cooler for sample transport, with "blue ice" or ice bags
- Appropriate sample Jars for planned testing or analyses (See Table 1)
- Sampling equipment such as scoops or spatulas. All equipment shall be stainless steel or teflon
- Organic Vapor Analyzer (OVA), OVM, TIP, H_2S meter or combustible gas detector with accessories and calibration gases (Optional depending on HASP requirements)
- Chain of Custody (Exhibit D)
- Sample Integrity Data Sheet (Exhibit C)
- Sample Labels and Seals (Exhibit E)
- Cleaning equipment and solutions

- Container(s) for capturing, containing and treating waste documentation solutions, if necessary
- Organic free distilled or deionized water
- Protective clothing and equipment as required by the HASP.

8. PROCEDURE

8.1 General Considerations

8.1.1 Project Briefing and Site Preparation

The Project Manager shall ensure that all Golder Associates and Contractor personnel are briefed on the importance of proper drilling and sampling techniques, decontamination procedures, health and safety requirements, and the other issues addressed by this technical procedure. All sampling activities shall comply with the individual work plans and the site Health and Safety Plan (HASP) requirements. All personnel shall be advised that unanticipated conditions may dictate changes in standard and accepted procedures as outlined in this technical procedure. All such variations shall be documented on a Field Change Request form (Exhibit F) and reviewed and approved as noted in Section 8.2.6 below.

All downhole drilling and sampling equipment shall be measured for correct length prior to use for the purpose of accurately measuring depth during drilling. Measurements shall be recorded by the Geologist/Engineer. All sampling equipment used to collect environmental soil samples shall be decontaminated prior to being used to collect a sample. Drilling equipment used to collect environmental soil samples must be decontaminated prior to being used on each borehole. Equipment used for engineering/geologic soil sample acquisition will require routine cleaning, but will generally not require decontamination as described in 8.1.2 below.

8.1.2 Decontamination of Environmental Sampling and Drilling Equipment

For environmental sampling investigations, sampling and drilling equipment must be thoroughly cleaned to avoid cross-sample contamination. Environmental soil sampling devices must be decontaminated prior to obtaining each sample; drilling equipment must be decontaminated prior to use on each borehole. Unless specified otherwise in project plans, tools and equipment shall be decontaminated by steam cleaning and/or by washing with a non-phosphate detergent and rinsing with distilled water. For inorganic analytes, a weak hydrochloric acid (HCI) solution shall be used for the second wash. For organic analytes, reagent grade methanol shall be used for the second wash. A final rinse with organic-free distilled/deionized water shall complete the decontamination. Wash and rinse fluids shall be collected; responsibility for disposal shall be defined in the governing project plans. Decontamination procedures shall be recorded by the Geologist/Engineer. The Geologist/Engineer shall be responsible for inspecting all decontaminated equipment to insure that decontamination procedures have been adequate.

8.1.3 Sample Quantities and Types

Samples shall be collected in quantities and types as directed by the Project Manager or as specified in the project work documents. The History of Hole (Exhibit A), Record of Borehole Log (Exhibit B) and the Sample Integrity Data Sheet (Exhibit C) shall be used as applicable to document daily site activities and sample collection. Note: When drilling and sampling for geotechnical purposes ONLY, the Sample Integrity Data Sheet is not required. Environmental samples shall be transferred to the analytical laboratory under formal Chain of Custody Forms (Exhibit D), which shall be documented and maintained in accordance with procedure TP-1.2-23, "Chain of Custody."

8.1.4 Sample Containers

The type of sample containers shall be specific to the needs of the project and shall be determined by the Project Manager. Sample containers for environmental soil samples are specific and vary greatly from those used routinely to collect geotechnical/geologic samples. The containers include wide mouth glass jars with teflon lined caps for potentially contaminated samples, or plastic jars for standard archived soil samples. Plastic bags may be used in some cases. The acceptable material for environmental soil sample containers depends on the planned analyses and is addressed in Table 1.

If an inner barrel liner is used, it may not be necessary to remove the sample material for transfer to a sample container. If liners are used for environmental samples, the sample material is left relatively undisturbed and the liner is sealed with teflon sheeting or aluminum foil and covered with plastic caps, then sealed with tape. If liners are used for geotechnical soil testing, paraffin or micro-crystalline wax may be used as a seal directly in contact with the sample (replacing the teflon sheeting or aluminum foil). The liner shall be labeled in compliance with Section 8.2.3 and permanently marked to indicate sample orientation in the borehole. Unfilled end sections of liners for geotechnical samples should be removed with a hacksaw or cutoff saw prior to capping and sealing, in order to prevent disturbance of core material. In the event that the Project Manager requires subcoring of samples in inner liners, either extract sample material from the center of the core without disturbing material on the liner sidewalls, or use a small diameter Shelby tube and hydraulic press to collect a subcore from the interior portion of the liner sample.

8.2 Documentation

Documentation for sampling soils includes the labelling of sample containers; and (depending on the type of sample), completing History of Hole forms, Record of Borehole logs, Sample Integrity Data Sheets, and Chain of Custody Records. Individual environmental samples or sample coolers shall be secured with chain of custody seals. The original field forms shall be submitted as soon as possible to the Document Custodian for filing. Copies shall be given to the Project Manager and Task Leader.

8.2.1 History of Hole Forms

A record of events related to each borehole shall be maintained by the Geologist/Field Engineer on the History of Hole form (Exhibit A). The purpose of this form is to document events associated with drilling each hole in case questions arise later. All events which could affect the successful and timely completion of a borehole should be recorded with the time interval the event occurred. All information available prior to the initiation of drilling a borehole should be recorded, including job number and location; borehole number; name of contractor, driller, and Geologist/Field Engineer; weather conditions; and temperature. Other data requested on the form shall be completed as it becomes available.

The names and responsibilities of people working at or visiting the site should be recorded, as well as the time of their arrival and departure. Other items that should be noted include the shift time, beginning and end of drilling or production time, down time, stand-by time, total footage drilled, quantities of supplies used (i.e., sand, grout, piezometer piping, etc.), depth water was encountered, and the number and type of samples taken.

8.2.2 Record of Borehole Log

The Record of Borehole log (Exhibit B) provides both a graphic and descriptive record of subsurface observations made during the drilling of the borehole. All immediately available information shall be filled out first; including borehole number, drilling date, drill rig, job number, contractor's name, driller's name, and Geologist/Field Engineer's name. Other information, such as elevation and location coordinates may be added later if they are not immediately known. The log may be modified by the Project Manager to include information such as station number, OVA scans, offset distance, and inclination of hole, to suit the needs of a particular project. Minor variations to this log have been used in the past and may be preferred for consistency for a particular client.

A scale which will allow enough space for soil descriptions shall be chosen and recorded in the first column under the heading "Depth Scale" starting at 0 feet. This scale shall be used to align the information across the form so that data can be easily related to the proper depth at which it was encountered. The method of drilling shall be recorded in the next column, marking the appropriate depths that the method was used. The next 3 columns (Soil Profile Description, Graphic Log, and USCS) may be left blank until the type of material has been determined and a change in soil type has been encountered. The Geologist/Field Engineer shall observe the soil cuttings coming out of the hole to make an approximation of depth of change. This may be verified by comparing samples on either side of the change. Top and bottom depths of each soil horizon shall be noted in the "Soil Profile Description" column, followed by a description of the material. A pictorial representation of the zone shall be sketched in the "Graphic Log" column, and material designation according to the Unified Soils Classification System (see Golder Associates TP-1.2-6, "Field Identification of Soil") be placed in the "USCS" column. A line shall be drawn across these 3 columns corresponding to the top and bottom depths on the Depth Scale. A straight line across the Graphic Log column represents a known depth of change, while a slanted line represents an approximate depth.

The sample number, type of sample taken, blow count, and percent recovery shall be recorded in the appropriate columns at the corresponding scaled depths. Lines shall be sketched across these columns to show top and bottom of the sample. Blow counts, if required, will be taken during Standard Penetration Tests (SPT), and shall be recorded for every 6 inches in an 18 inch sample. The percent recovery shall be recorded as a fraction, i.e., the number of inches recovered over the number of inches sampled. If a non-standard drive tube sampler or drive force is used, record the details associated with the penetration tests.

Each sample shall be described according to TP-1.2-6, "Field Identification of Soil", and recorded in the Sample Description column. The sample number should be recorded first, followed by the sample interval depth, and then the description. An effort should be made to line the descriptions up with the corresponding scaled depth; however, it is much more important that all pertinent information be recorded. This column is also the appropriate place to make notes which may prove to be important in the later analysis, such as the depth of the water table, definite changes in drilling speed, unexpected materials or odors coming up with the cuttings, chemical staining, OVA or OVM scans of samples or excessive jarring of the sample.

In the event that a piezometer or monitoring well is installed in the hole, a graphic representation of the installation may be drawn showing the bottom of the casing in relationship to the bottom of the hole, screened zones, bentonite seals, sand back fill, and other back fill zones if applicable. Piezometers and monitoring wells shall be constructed in accordance with applicable Golder Associates technical procedures and governing state regulations.

8.2.3 Sample Labels

Samples shall be immediately labelled (see Exhibit E for an example). Labels shall be water proof. Information shall be recorded on each label with indelible ink. All blanks shall be filled in (N/A if not applicable). Soil sample designations will be as specified in the project work documents or by the Project Manager.

8.2.4 Sample Integrity Data Sheets

Sample Integrity Data Sheets (Exhibit C) shall be used by the Geologist/Field Engineer to document the official raw field information for each environmental sample that will be chemically analyzed. All blanks shall be filled in (N/A if not applicable).

8.2.5 Chain of Custody Records

Chain of Custody Records (Exhibit D) will be used to record the custody and transfer of environmental samples in accordance with procedure TP-1.2-23, "Chain of Custody." These forms shall be filled in completely (N/A if not applicable). Tamper-proof Seals (Exhibit E) shall be placed on either sample bottles or shipping coolers in a manner such that accessing a sample will break the seal. The seal number shall be recorded on the Chain of Custody Form. The original form must accompany the samples to the analytical laboratory to be completed and returned to Golder for filing by the Document Custodian. A copy of the Chain of Custody Record documenting the transfer of samples from the field shall be submitted to the Document Custodian for filing.

8.2.6 Field Change Request

Variation from established procedure requirements may be necessary due to unique circumstances encountered on individual projects. All variations from established procedures shall be documented on Field Change Request form (Exhibit F) and reviewed by the Project Manager and the QA Manager.

The Project Manager may authorize individual Geologist/Field Engineers to initiate variations as necessary. If practical, the request for variation shall be reviewed by the Project Manager and the QA Manager prior to implementation. If prior review is not possible, the variation may be implemented immediately at the direction of the Geologist/Field Engineer, provided that the Project Manager is notified of the variation within 24 hours of implementation, and the Field Change Request is forwarded to the Project Manager and QA Manager for review within 2 working days of implementation. If the variation is unacceptable to either reviewer, the activity shall be reperformed or action shall be taken as indicated in the Comments section of the form.

All completed Field Change Requests shall be maintained in project records.

8.3 Soil Sample Acquisition

8.3.1 Drilling Methods

Many types of drilling methods exist for the purpose of advancing boreholes through soil or other unconsolidated deposits. Unconsolidated deposits present special drilling problems due to the nature of the material, specifically a tendency to collapse. The Project Manager shall determine the most appropriate technique for the types of material expected to be encountered. The most commonly used methods include hollow stem augering, air or mud rotary drilling, and cable tool drilling. Drilling methods are discussed in detail in Appendix A.

8.3.2 Sampling Considerations

Sampling shall start at the ground surface and continue at depth intervals as specified in the project work plan or as directed by the Project Manager. Unless otherwise directed by the Project Manager, drill sample cuttings from rotary drilling rigs shall be obtained at the surface and at 5 feet depth intervals or in each distinct stratum. For auger drilling rigs, drive tube samples shall be collected at 5 feet depth intervals. Additional environmental soil samples (in addition to specified samples in project plans) may be collected in strata where contaminants potentially could accumulate.

The sampler shall be removed from the hole avoiding excess jarring to the sampler when breaking the drill rods, as such jarring may result in loss of all or a portion of the sample. Excess jarring also disturbs the integrity of samples intended to be undisturbed samples, making test results on soil strengths erroneous. Excess jarring of in situ samples should be noted on the Record of Borehole (Exhibit B).

Procedures for managing poor recovery shall be established with the Project Manager prior to initiating drilling and sampling activities. If a sample is lost or poor recovery is realized (defined as more than 50 percent missing from the sampled length), the following minimum procedures shall be followed:

1) The Geologist/Field Engineer shall confirm that the appropriate sample catcher and ball check valve are in operating order, unless other types of sampler arrangements are specified by the Project Manager.

2) The boring shall be advanced to the bottom of last sample interval and a second sample attempt made after considering adjustments to the sampling technique for improving recovery. Adjustments may include:

   - The frequency of blows used to advance the sampler.
   - Letting the sampler "rest" after being driven the 18-inch sample interval.
   - Placing a plastic "sock" around the sample catcher.
   - Pushing the sampler rather than driving with a hammer.
   - Design of the catcher.
   - Condition of the sampler shoe, replace if necessary.

3) If poor recovery continues, contact the Project Manager or refer to project- or site-specific directions.

There are a variety of samplers which may be used on drilling projects, each with its own purpose and advantages. Several of the most widely used samplers are described in Appendix B along with guidelines for their use. The Project Manager is responsible for selecting the sampling method(s) most desirable for the project.

8.3.3 Sample Logging

All samples, whether in situ or disturbed, shall be inspected and logged by the Geologist/Field Engineer. The soil shall be classified according to the procedures presented in TP-1.2-6, "Field Identification of Soil", and recorded on the Record of Borehole (Exhibit B).

For environmental soil samples, additional descriptions such as odor, staining, oily sheen, etc. should be noted on the log. Scanning the collected soils samples may also be done with and OVA, OVM or equivalent if volatile organics are present. These scan readings should be noted on the Record of Borehole at the corresponding depth.

8.3.4 Interim Sample Storage and Shipment

Interim sample storage and shipment requirements shall be defined by the Project Manager and reviewed with the Geologist/Field Engineer prior to mobilization to the field. Unless otherwise directed by the Project Manager, minimum storage requirements shall be as follows:

- all environmental samples, in any type of container, shall be stored and shipped in an insulated cooler at 4°C $\pm$ 2°C;
- all environmental, permeability and moisture content samples shall be protected from freezing during storage and shipment;
- all Shelby tubes or ring-lined barrel tubes shall be sealed with paraffin, or micro-crystalline wax, capped, and taped;
- all lexan inner liners shall be capped and taped, and shall be stored out of direct sunlight;
- all Shelby tubes and lexan inner liners shall be stored vertically;
- all moisture-content samples shall be stored in airtight jars or double-bagged in plastic, with as much air as possible evacuated from the bags;
- all samples shall be stored in a safe place to preclude any loss or disturbance;
- undisturbed engineering/geological samples shall be protected with resilient packaging material to reduce shock, vibration and other physical disturbance of the sample during shipment; and
- all environmental samples shall be stored in a locked storage area, or shall remain in view of the responsible Geologist/Field Engineer or sampler until transfer of chain-of-custody documentation and samples to the analytical laboratory. If it is necessary to keep the samples in a vehicle, the vehicle will be kept locked when unattended.

8.4 Abandonment of the Borehole

Boreholes shall be abandoned in compliance with applicable regulatory requirements, project work plans, or client requirements; abandonment methods and materials shall be defined by the Project Manager and shall be documented by the Geologist/Field Engineer on the History of Hole form (Exhibit B). If monitoring wells or piezometers are to be installed, refer to the applicable Golder Associates technical procedures and state regulations for further direction.

8.5 Capture and Disposal of Soil Drill Cuttings and Decontamination Solutions

Soil drill cuttings, contaminated groundwater and decontamination waste solutions produced during the drilling and sampling operations must be disposed of in accordance with Local, State, and Federal regulations and shall be specified in the project work documents. Decontamination waste solutions that are generated during soil sampling include: spent detergent wash solutions; spent tap water rinses; any spent weak acid rinses, any spent methanol rinses; and spent final distilled/deionized water rinses. All spent acid and methanol rinses shall be captured and contained in plastic buckets or drums. Other spent decontamination waste solutions shall be captured and contained in appropriately sized buckets or drums, if a reasonable potential exists for the spent solutions to contain hazardous substances. Project work documents shall address or the Project Manager shall determine whether spent decontamination solution require capture and containment.

If required, decontamination waste solutions and contaminated soils shall be captured and contained in 55 gallon steel drums or suitable tanks. Liquid and solid waste should be segregated into separate containers. If required, each drum or tank shall be properly labelled with a weather proof label as to contents, borehole number, borehole interval contained in container, and date in which contents were generated. Storage and ultimate disposal of drums or tanks shall be specified in the project work documents or as directed by the Project Manager. Some noteworthy variances are as follows: (1) all acid solutions shall be neutralized with lime prior to discharge or disposal; (2) methanol solutions may be able to be evaporated, if segregated from other waste solutions, if generated in small enough quantities, and if conditions are favorable; and (3) if quantities are sufficiently small, decontamination waste solutions (detergent washes, rinse waters, neutralized acid solutions) may be added to the captured and contained soils that corresponds to the same soil sampling effort.

TABLE 1

TP-1.2-5
SAMPLE CONTAINERS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES FOR ENVIRONMENTAL SOIL SAMPLES

Contaminant	Container	Preservation	Holding Time
Acidity	P,G	Cool, 4°C	14 days
Alkalinity	P,G	Cool, 4°C	14 days
Ammonia	P,G	Cool, 4°C	28 days
Sulfate	P,G	Cool, 4°C	28 days
Sulfide	P,G	Cool, 4°C	28 days
Sulfite	P,G	Cool, 4°C	48 hours
Nitrate	P,G	Cool, 4°C	48 hours
Nitrate-Nitrite	P,G	Cool, 4°C	28 days
Nitrite	P,G	Cool, 4°C	48 hours
Oil and Grease	G	Cool, 4°C	28 days
Organic Carbon	P,G	Cool, 4°C	28 days
Metals			
Chromium VI	P,G	Cool, 4°C	48 hours
Mercury	P,G	Cool, 4°C	28 days
Metals except above	P,G	Cool, 4°C	6 months
Cyanide	P,G	Cool, 4°C	28 days
Organic Compounds			
Extractables (including phthalates, nitrosamines organochlorine pesticides PCB's nitroaromatics, isophorone, polynuclear aromatic hydrocarbons, haloethers, chlorinated hydrocarbons and TCDD)	G, teflon-lined cap	Cool, 4°C	7 days (until extraction) 30 days (after extraction)
Extractables (phenols)	G, teflon-lined cap		
Purgeable (halocarbons and aromatics)	G, teflon-lined septum	Cool, 4°C	14 days
Purgables (acrolein and acrylonitrate	G, teflon-lined septum	Cool, 4°C	3 days
Orthophosphate	P,G	Cool, 4°C	48 hours
Pesticides	G, teflon-lined cap	Cool, 4°C	7 days (until extraction)
Phenols	G	Cool, 4°C	28 days
Phosphorus	G	Cool, 4°C	48 hours
Phosphorus, total	P,G	Cool, 4°C	28 days
Chlorinated organic compounds	G, teflon-lined cap	Cool, 4°C	7 days (until extraction) 30 days (after extraction)

P = polyethylene G = glass
Source: USEPA Soil Sampling Quality Assurance User's Guide, 2nd Edition, USEPA/600/8-89-046

Golder Associates

HISTORY OF HOLE

Job No. ____________ Sheet ______ of ______

Geologist ____________ Date ____________ Boring No. ____________

Driller ____________ Surface Elevation ____________ Weather ____________ Temp ____________

Contractor ____________ Drill Fluid ____________ ____________ To ____________

Location ____________ Type of Barrel ____________ Casing Size ____________ Core Size ____________

BEGINNING OF SHIFT	END OF SHIFT
Time ______ Depth of Hole ______	Time ______ Hrs Productive ______ Hrs. Delayed ______
Depth to WL ______ Depth of Casing ______	Depth of Hole ______ Depth of Casing ______ Depth to WL ______

Checked by:

EXHIBIT A

HISTORY OF HOLE

TP-1.2-5

PROJECT NO.

RECORD OF BOREHOLE

SHEET OF
DATUM
DRILL RIG

LOCATION:

ELEVATION
DRILLING DATE

DEPTH FEET	BORING METHOD	SOIL PROFILE: SOIL PROFILE DESCRIPTION	GRAPHIC LOG	USCS	SAMPLES: NUMBER	TYPE	BLOWS / 6 IN.	RECOVERY	SAMPLE DESCRIPTION	NOTES / PIEZOMETER / STANDPIPE INSTALLATION

DEPTH SCALE
DRILLING CONTRACTOR
DRILLER

Golder Associates

LOGGED BY
CHECKED
DATE

EXHIBIT **B**
RECORD OF BOREHOLE
TP-1.2-5

SAMPLE INTEGRITY DATA SHEET

Golder Associates

Plant Site ______________________ Project No. ______________________

Site Location ______________________ Sample ID ______________________

Sampling Location ____

____

Technical Procedure Reference(s) ______________________________

Type of Sampler ____

Date ______________________ Time ______________________

Media ______________________ Station ______________________

Sample Type: grab time composite space composite

Sample Acquisition Measurements (depth, volume of static well water and purged water, etc.) __________

____

____

____

Sample Description ____

____

____

Field Measurements on Sample (pH, conductivity, etc.) ______________

____

____

____

Aliquot Amount	Container	Preservation/Amount

Sampler (signature) ______________________ Date ______________________

Supervisor (signature) ______________________ Date ______________________

Golder Associates Inc.

EXHIBIT **C**
SAMPLE INTEGRITY DATA SHEET
TP-1.2-5

PROJ. NO.	SITE/LOCATION
SAMPLER/LAB TECH *(Signature of Initiator)*	

STA. NO.	DATE	TIME	SAMPLE TYPE	MEDIA	IDENTIFICATION	NO. OF CONTAINERS	AMOUNT/ PRESERVATIVE						SEAL NO.	SEAL INTACT? (Y or N)	REMARKS *(With Initials)*

DESTINATION:	VIA:

ACKNOWLEDGEMENT OF RECEIPT DUE BY:

Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*	Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*
Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*	Relinquished by: *(Signature/Firm)*	Date/Time	Received by:

Return Completed Form To:	Remarks: *(Attachments if necessary)*

EXHIBIT **D**

CHAIN OF CUSTODY RECORD

Golder Associates

Location ______________________

Job No. __________ Date __________

Boring No. __________ Sample No. __________

Depth __________ Blows __________

Description ______________________

____

____

____

Driller __________ Engr. __________

Geotechnical Sample Label

Golder Associates
Seal Number
2455

Golder Associates

Sent By: __________

Date: __________

Tamper Proof Seal

FIELD CHANGE REQUEST

Golder Associates

Job/Task Number: ______________________________

Other Affected Documents: ______________________________

Requested Change: ______________________________

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

Reason for Change: ______________________________

____

____

____

____

Change Requested by: ______________________________ Date ______________

Reviewed by: ______________________________ Date ______________
GAI Project Manager

Comments: ______________________________

____

____

____

Reviewed by: ______________________________ Date ______________
GAI QA Manager

Comments: ______________________________

____

____

____

APPENDIX A

DRILLING METHODS

1. GENERAL DRILLING CONSIDERATIONS

Many types of drilling techniques exist for advancing boreholes in unconsolidated deposits. The methods described below include the hollow stem auger method, air rotary drill and drive, and cable tool drilling methods and hydraulic direct push methods. This list is not intended to be all inclusive. Unconsolidated deposits present special drilling problems due to the nature of the material, and the Project Manager shall determine the most appropriate drilling technique for the types of materials expected to be encountered. The drilling method selected shall provide a reasonable opportunity to notice gross material changes and to make periodic depth soundings at the point at which the phreatic ground water level is encountered. Borehole instability or the tendency of the hole to collapse is common to all drilling methods in unconsolidated deposits.

All drive casing used in the drilling operation shall be of such design and wall thickness as to prevent collapse or deformation when driven through the in situ materials. All welding of drive casing or alternate approved methods of joining the casing shall follow acceptable practices to prevent separation at joints. If welding is employed, all welds shall have a minimum of three passes made on the weld joint and have a minimum of three "star welds."

For environmental investigations and the collection of environmental soil samples, some care must be exercised in the selection of the drilling method to insure representative samples. Grease or oil based lubricants may not be used on any drilling equipment that enters the borehole. Drill rigs must be adequately cleaned and decontaminated prior to setting up on each borehole. Any water introduced into the borehole during the drilling operation must be from an approved source and additional drilling additives will generally not be used. Compressed air used during air rotary drilling may need to be filtered depending on the analyte of concern.

2. METHODS

2.1 Hollow Stem Auger Method

The hollow stem auger method consists of advancing continuous flight augers into the ground. The terminal flight section is equipped with a drill bit or cutting teeth. In situ soils are sampled through the center of the hollow stem. Drill cuttings are brought to the surface by the "screw conveyor" action of the auger flights. Borehole stability is established by the augers. The maximum depth of penetration is usually 100 ft., although 160 to 180 foot drilling depths have been achieved in certain geologic materials. Auger flights are joined by clamping pins or by screw fittings. Grease shall not be used on the joints for lubrication if the particular project is an environmental investigation.

2.2 Air Rotary Drill and Drive

The air rotary drill and drive technique employs a tri-cone roller bit, pneumatic downhole hammer, or both, on drill rods to achieve penetration. Steel drive casing (usually 0.25 inch minimum wall thickness) is advanced for borehole stability directly behind the bit/hammer by driving with a pneumatic casing hammer. The drive casing is connected either by welding or flush coupled threaded joints. The terminal end of the drive casing is equipped with a hardened steel drive shoe for strength during penetration. Drill cuttings are removed from the borehole by circulating high volume compressed air to the bottom of the borehole through the drill rods and blowing the cuttings to the surface within the annular space between the rods and casing. On environmental investigations the air from the compressor must be filtered to remove the entrained oil before downhole use. In situ soils may be sampled through the drive casing after the bit/hammer and drill rods are removed from the borehole. Maximum depths for this drilling method depend of the size of the rig and compressor, but are normally greater than 300 feet. Air rotary drilling is not recommended for volatile organic sampling due to the "air stripping" action of the drilling operations.

2.3 Cable Tool Drilling

Cable tool drilling is slow, but offers some advantages for sampling. The technique employs a heavy downhole chopping bit which is dropped onto the underlying sediments to loosen the materials. The bit is connected to the drill rig by a wire (cable) line. The drill rig activates the up and down action for the bit. Steel drive casing (usually 0.25 inch minimum wall thickness) is advanced for borehole stability directly behind the downhole bit. The casing is driven by a hammer and anvil using the same up and down action of the drill rig. The steel drive casing sections are connected either by welding or flush coupled threaded joints. The terminal end of the drive casing is equipped with a hardened steel drive shoe for strength during penetration. Cuttings are allowed to accumulate until they start to lessen the impact of the bit and then are removed with a sand bailer or sand pump. In situ soils are sampled through the drive casing after the bit is removed from the borehole. It is necessary to add water to the borehole in the vadose zone for bailing cuttings from the hole. In environmental investigations, the composition of the added water must be known, particularly with regard to the analytes of concern.

2.4 Hydraulic Direct Push Technology

The hydraulic direct push technology is operated by a rugged, lightweight hydraulic drive point system mounted on a four wheel drive truck, designed to perform sampling and monitoring services specific to the environmental industry. This sampling technology is typically referred to by it's trade names of GEOPROBETM or STRATAPROBE™.

The direct push hydraulic unit consists of a rear-mounted, dual ram configuration mounted in conjunction with a vibrating component that is capable of producing high-frequency impact energy. STANLEY 90 lb.-150 lb. hydraulic drive hammers are standard equipment in all STRATAPROBEs. A 5,000 pound static reaction weight and 15,000 pound pullback capacity provide ample force to overcome most common geologic conditions. A low profile mast, typically less than twelve feet high when fully extended, and the framework of the machine is boom articulated to allow for a full range of positioning, including up to a 20 degree angle for boring underneath structures. The hydraulic direct push equipment can drive an assortment of sampling devices to fifty feet in many soil formations.

2.4.1 Operation

The STRATAPROBE and Geoprobe units are typically operated from a station at the rear of a 1-ton pickup truck. The probing unit is hydraulically powered via a power takeoff pump mounted directly to the truck's transmission. Positioning, pushing, and retracting of the probe and hammer is controlled by two separate hydraulic control manifolds located at the operating station. Each manifold consists of four to six spring-return to neutral control valves. The spring return feature provides a safety function which stops all probing and positioning action if the operator releases the valve.

2.4.2 Soil sampling procedures

Discrete interval soil samples may be obtained by using either of two primary methods, a 2.0 inch O.D. (outside diameter) x 36-inch overall length coring tube or 2.0-inch O.D. x 24 inch (nominal) overall length discrete piston sampler.

The samplers are threaded onto the leading edge of STRATAPROBE 1.5-inch O.D. probe rod and advanced to depth using the STRATAPROBE direct push system. The probe rods are nominally 4-feet in length and additional rods are connected to reach the desired depth. Upon reaching the desired depth, the retractable piston is unlocked and the sampler is advanced into the soil to collect the sample. Soil samples are retrieved by retracting the probe rod and sampler to the surface and disassembling the sampler.

Continuous coring can also be accomplished via a cased continuous coring system. This allows a 2″ diameter casing and a 2′ split barrel sampler to be simultaneously driven. When the sampler is withdrawn, the casing stays in place. The next 2′ split barrel sampler is then lowered into the casing, and the system is advanced another 2′ and so on until the desire depth is reached. This is an extremely clean method of coring. When using a fall-off shoe on the casing, a 1″ miniwell can be place in the cased hole upon completion of the boring. The casing is then withdrawn and the resulting well is packed with sand and bentonite.

Samples are obtained in industry standard 1.5-inch sleeves made of brass, stainless steel, or acetate. The sleeves are removed from the sampler, and capped on both ends for transport to a laboratory for analysis. A piece of Teflon material can also be placed between the sleeve ends and the caps.

Sampling rates vary from 100′ to 200′ per day depending on soil conditions. Use of the coring tube provides for observation of subsurface conditions.

APPENDIX B

SAMPLING METHODS

1. SPLIT-BARREL METHOD

1.1 Sampling Equipment Requirements

- split-tube samplers constructed in accordance with ASTM-D-1586, "Penetration Test and Split-Barrel Sampling of Soils" (see Figure B-1); 2, 4, and 6 inch diameter samplers should be available; all samples shall be fitted with hardened drive shoes and basket retainers.

- drive weight assembly constructed in accordance with ASTM-D-1586, affixed to a length of drill rod for advancing the sampler

- stainless steel spatulas

- sample containers as required

- sand catch or trap (optional)

- lexan inner barrel liners, caps, and tape, as required

1.2 Method

The sampling horizon may be exposed by any drilling technique that will produce suitable wall clearance for insertion of the sampler. Depth to the sample horizon shall be measured using the combined lengths of the downhole tools, drill rod or auger flight lengths, and amount of stickup above the drill collar. Particular attention must be paid to the calculated depth to ensure that the sampler is resting on the desired sample interval. Sampler diameter selection shall be based on geologic logging observations. 2-inch diameter samplers are appropriate for nonlithified clays, silts, sands and fine gravels; 4- or 6-inch samplers shall be selected for zones with coarse gravels and cobbles, or when larger sample volumes are required. Samplers shall be driven 18 inches with the drive weight (noting the weight of the hammer being used); blow counts for the first 18 inches of penetration shall be recorded in 6-inch increments, counted, and recorded on the Borehole Log. The downhole bit or auger, the split tube sampler and any liners and the stainless steel spatula shall be decontaminated prior to use.

2. THIN-WALLED ("SHELBY") TUBE SAMPLING METHOD

2.1 Sampling Equipment Requirements

- thin-walled metal sample tubes, manufactured in compliance with ASTM-D-1587, "Standard Practice for Thin-Walled Tube Sampling".
- aluminum foil or teflon sheeting, tube end caps, tape or seals, as required
- sample containers, as required
- stainless steel spatulas, if contents of tube are examined and transferred to sample containers at the surface prior to transfer to the laboratory
- micro-crystalline wax or paraffin, as specified by the client.

2.2 Method

This method is normally used to obtain undisturbed samples of cohesive soils for geotechnical analysis, although thin walled sampling techniques (commonly referred to as Shelby tube techniques) may also be used to sample other cohesive materials such as sludges for environmental assessments. Sampling methods should be in general accordance with ASTM-D-1587, "Standard Practice for Thin-Walled Tube Sampling of Soils." Any drilling technique is acceptable to expose the sampling horizon provided that sufficient clearance is present to permit insertion of the sampling equipment. Depth measurements shall be based on cumulative measurements of drill rods or auger flights, downhole tool length, and amount of stick up at the drill collar. Particular attention must be paid to the depth calculations to ensure that the sampler is resting on the desire sample interval. The sample tube is attached to an appropriate Shelby head subassembly, which is then connected to the drill rods, or auger flights, inserted to a maximum of 15 tube diameters by steady pressure with no rotation. Depending upon soil conditions the tube will be left in place for a period of time (5-10 minutes) to dissipate negative pressure prior to withdrawal of the tube. Depending on project-specific requirements, the sample tube may be capped labeled and sealed at the surface and routed directly to the laboratory. Alternately, the sample may be exposed at the surface, removed with a stainless steel spatula and transferred to a suitable container after visual examination. The downhole drilling tool, insertion tool, sample tube, and stainless spatula shall be decontaminated prior to use.

3. DRIVE TUBE (RING-LINED BARREL OR "CALIFORNIA") SAMPLING METHOD

3.1 Sampling Equipment Requirements

- drive tube (ring-lined barrel) assembly manufactured in compliance with ASTM-D-3550, "Ring-Lined Barrel Sampling of Soils" (see Figure B-2)
- sampler barrel with removable rings
- surface or downhole drive weight assembly
- stainless steel spatulas
- sample containers as required
- sand catch or trap (optional)
- inner barrel liners, aluminum foil or teflon sheeting caps, and tape, as required

3.2 Method

This method is normally used to obtain relatively undisturbed geotechnical samples, although this technique is useful in obtaining samples when volatile organic compounds are among the analytes of concern.

The sampling horizon may be exposed by any drilling technique that will produce suitable wall clearance for insertion of the sampler. Depth to the sample horizon shall be measured using the combined lengths of the downhole tools, drill rod or auger flight lengths, minus the amount of stick up above the drill collar. Particular attention must be paid to the depth calculations to ensure that the sampler is resting on the desired sample interval. Samplers shall be driven 18 inches with a surface or downhole drive weight assembly (noting the weight of the hammer being used); sampler insertion should be by pushing in lieu of driving wherever possible. If required by project-specific requirements, blow counts of the first 18 inches of penetrations shall be counted and recorded in 6-inch increments on the Borehole Log. The sampler shall be retrieved and carefully disassembled. Trim the soil flush with the sampling barrel with the spatula, and remove the specimen-filled rings. Place each ring in a suitable container and cap and seal with clean aluminum foil at both ends. Downhole samplers and stainless steel spatulas shall be decontaminated prior to use.

4. DOUBLE TUBE (DENNISON OR PITCHER) SAMPLING METHOD

4.1 Sampling Equipment Requirements

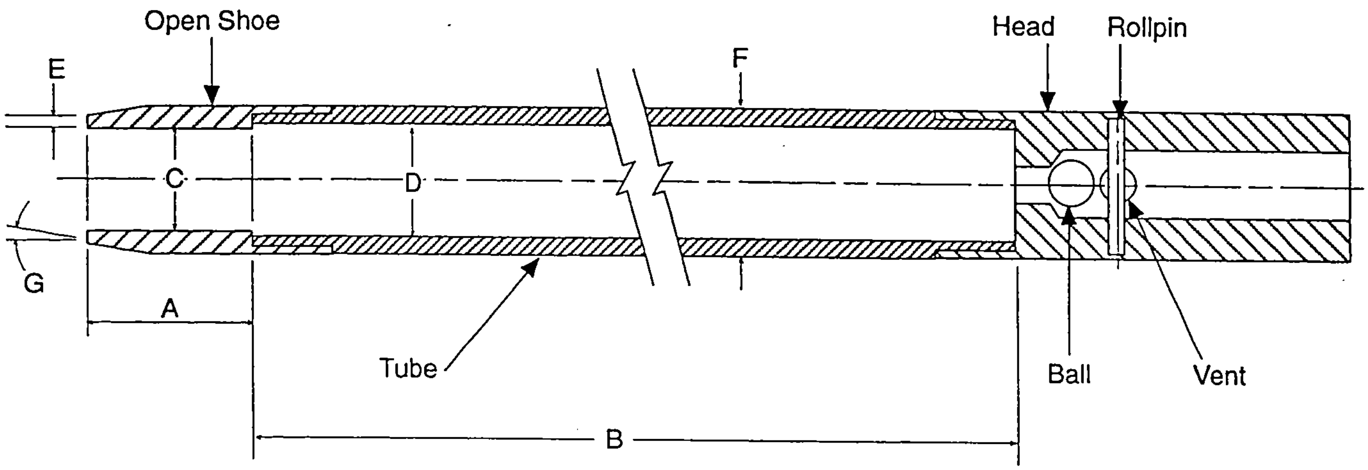
- thin-walled brass or stainless steel sample tubes (Shelby tubes) designed to be used with the selected sampler assembly
- Dennison or Pitcher sampler assemblies (see Figure B-3; generally provided by the driller)
- aluminum foil, teflon sheeting, plastic tube end caps, tape, seals, labels, and paraffin or microcrystalline wax, as specified by the client, Project Manager, or applicable work plan, for sample sealing purposes
- sample containers, as required
- stainless steel spatulas and mixing bowls, if contents of the tube are to be examined and transferred to sample containers at the surface prior to transfer of custody to the laboratory

4.2 Method

Double tube sampling methods may be employed to obtain relatively undisturbed samples in formations that are too consolidated to accommodate drive-tube samplers; they may also be used as an option if split-barrel methods yield poor recovery. Any drilling method is acceptable to expose the sampling horizon provided that the annular clearance is adequate to permit insertion of the sampler assembly. Depth measurements shall be based on cumulative measurements of drill rods or auger flights, downhole tool length, and the amount of stick up at the drill collar. Particular attention must be paid to the depth calculations in order to ensure that the sampler is resting on the desired sample interval.

The primary advantage of the piston-type sampler is that the inner barrel and liner (Shelby tube) are prevented from rotating. The outer tube is fitted with a cutter that is rotated to remove the surrounding soil; the inner barrel does not rotate, but has a shoe with a hardened cutting edge that is advanced with the outer barrel. Choice of samplers shall be as specified by the Project Manager, the client, and/or the applicable work plan. The Dennison sampler (see Figure B-3) is designed so that the amount of protrusion of the inner barrel shoe relative to the face of the cutter on the outer barrel can be varied from zero to several inches by changing coring shoes. As a general rule, a flush setting is used in very stiff, dense, or brittle, soils; the maximum extension would be used in softer, more unconsolidated soils. The Pitcher sampler (see Figure B-3) is similar to the Dennison sampler except that the amount of protrusion is not preset, but can vary in relationship to the downward pressure on the drill string and the amount of spring tension in the sampler assembly. With the Pitcher sampler, there is constant pressure on the outer barrel cutter and the amount of inner barrel lead is regulated by the density of the formation. In unconsolidated formations, the inner shoe will protrude ahead of the cutter by several inches; in stiffer formations, the inner shoe will be forced back flush with the cutter. The sample is immobilized by a basket-style retainer.

If undisturbed samples are required, the Shelby tube may be capped, sealed, labeled, and routed directly to the laboratory. Alternately, the sample may be exposed, removed with a stainless steel spatula, and transferred to an appropriate sample container after completion of visual examination. The sampler assembly, Shelby tube, and (as applicable) sample spatula and mixing bowl shall be decontaminated prior to each use.



A = 1.0 to 2.0 in. (25 to 50 mm)

B = 18.0 to 30.0 in. (0.457 to 0.762 m)

C = 1.375 ±0.05 in. (34.93 ± 0.13 mm)

D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)

E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)

F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)

G = 16.0° to 23.0°

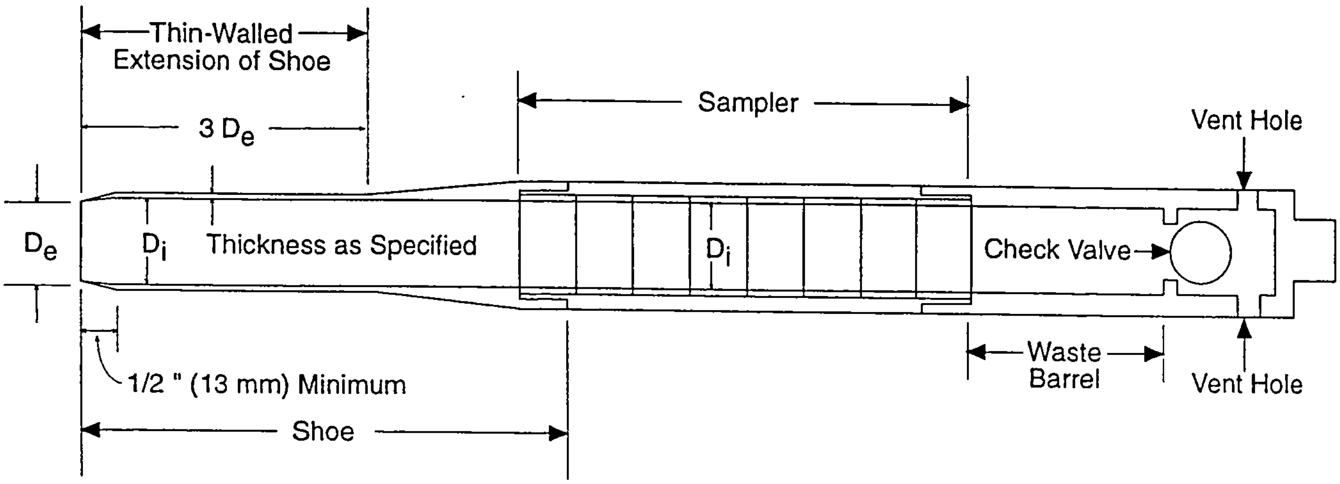
The 1 1/2 in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

REFERENCE: 1995 Annual Book of ASTM Standards, Volume 04.08, ASTM-D-1586.

FIGURE **B-1**

SPLIT BARREL SAMPLER

TP-1.2-5



Note 1 - Inside clearance ratio = $(D_i - D_e)/D_e$

Note 2 - Dimensional tolerance of $D_i = \pm 0.003$ in. (± 0.08 mm)

REFERENCE: 1995 Annual Book of ASTM Standards, Volume 04.08, ASTM-D-3550.

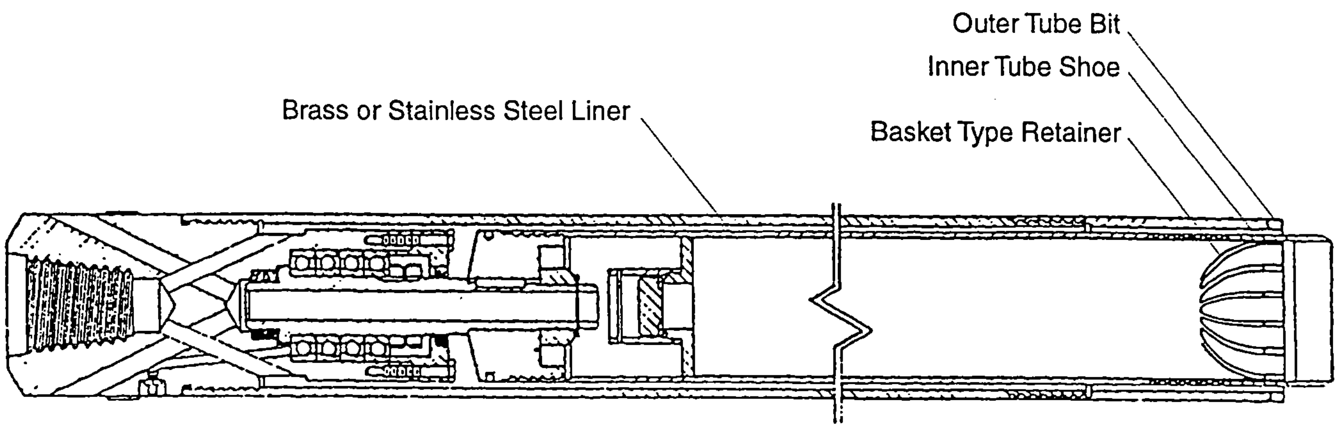
FIGURE **B-2**

RING-LINED BARREL SAMPLING ASSEMBLY

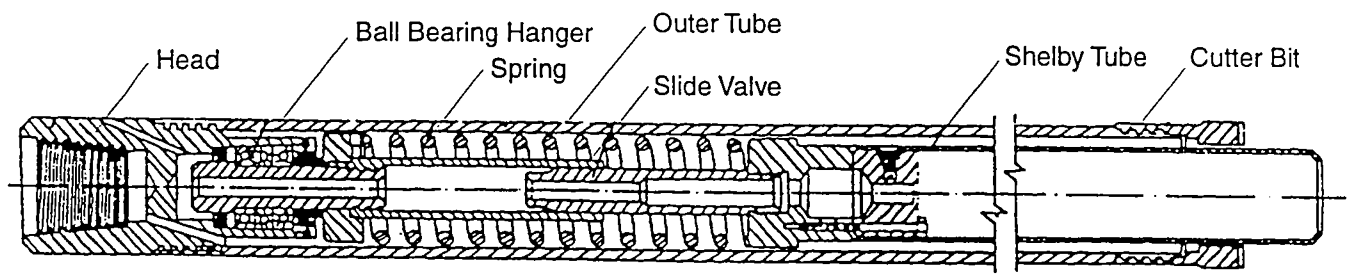
TP-1.2-5

PROJECT NO. IP3 1024 DRAWING NO. 66687 DATE 4/19/96 DRAWN BY EA

Golder Associates



Dennison Sampler



Pitcher Sampler

FIGURE **B-3**
DENNISON OR PITCHER SAMPLER ASSEMBLIES
TP-1.2-5

Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

TITLE TP-1.2-17 RISING HEAD SLUG TEST			EFFECTIVE DATE	REV. LEVEL
PREPARED BY	APPROVED	APPROVED 6/25/86	6/25/86	1

UNCONTROLLED COPY
The hard copy of this document is not controlled and may be obsolete.
Verify current revision level prior to use.

1.0 PURPOSE

This Technical Procedure is to be used to establish a uniform procedure for executing a rising head slug test.

2.0 APPLICABILITY

This Technical Procedures is applicable to all persons or parties involved with rising head slug testing.

3.0 DEFINITIONS

3.1 Rising Head Slug Test: A controlled field experiment conducted in a single borehole to determine the hydraulic properties of water-bearing rocks. The test is performed by measuring water level recovery in a well as a function of time, following near instantaneous withdrawal of water.

3.2 Measuring Point: A permanent point to which water level measurements are referenced. Top of the borehole casing is commonly utilized as a measuring point.

3.3 Drawdown: Change in water level from static condition.

4.0 REFERENCES

Bouwer, Herman, 1978. Groundwater Hydrology, McGraw-Hill, Inc., pp. 114-117, (Appendix A).

5.0 DISCUSSION

The outline of this procedure assumes negligible drawdown of the water table around the well and no flow above the water table.

6.0 RESPONSIBILITY

6.1 Each Field Engineer performing a rising head slug test shall be responsible for proceeding with testing in compliance with this technical procedure.

6.2 Task Leader shall be responsible for:

- o Direct supervision of personnel performing the test.
- o Assurance that equipment and materials are available to permit accomplishment of the task.
- o Determine duration of water level monitoring.
- o Determine time intervals between readings, and depth of suction hose.

7.0 EQUIPMENT AND MATERIALS

7.1 Data sheets for slug test-field record (Exhibit A)

7.2 Water level sounder accurate to a minimum of 0.03 feet.

7.3 Stop watch.

7.4 Field notebook

7.5 Folding rule or spring-wound tape measure.

7.6 A pump or bailer of suitable design to evacuate the water from the well bore rapidly.

7.7 Hoses of sufficient length and annular rigidity to convey water under expected pressures (if using a pump).

7.8 Semilog graph paper.

8.0 PROCEDURE

8.1 Record data at top of Rising Head Slug Test Field Record data sheets (Exhibit A).

8.2 Monitor water level for a time period of at least 1/4 of the anticipated test duration to determine static water level or water level trends. Refer to Golder Associates Quality Assurance TP-1.4-6 for instructions on measurements of water levels. Measurements shall be taken as depth below a specific permanent measuring point (i.e. northwest rim top of casing).

8.3 Use water level sounder to sound depth of water and record.

8.4 Insert pump suction line, or bailer, down casing to predetermined depth and record water level.

8.5 If using a pump, start pump and operate at full throttle. When water level reaches suction intake start stop watch and remove suction line from well casing; then shut off pump.

8.6 If using a bailer, rapidly remove bailer from hole. Start stop watch when bailer begins to be removed from the hole.

8.7 Monitor and record rising water levels and their time of occurrence as frequently as possible until the static water level is reached.

8.8 Check data by plotting log drawdown versus time.

8.9 Deem test unsuccessful and reapply if less than 3 points were recorded, or if data do not plot with reasonable linearity (see Bouwer, 1978, p. 117).

8.10 Calculate geometric factors necessary for data analysis and record on Exhibit B, "Geometric Factors for Rising Head Slug Test Analysis".

8.11 Perform data analysis as described by Bouwer, 1978 (see Appendix A).

Job No. ____________
Job Name ____________
By ____________
Date ____________

EXHIBIT A

RISING HEAD SLUG TEST FIELD RECORD

Well Identification____________________ Test No.________________

Measuring Point Description______________________________________
Measuring Point Elevation________________ (datum:)_______________

Radius of Well Casing (r_c)______________________________________
Radius of Well plus developed zone outside casing (r_w)____________

Depth of Well (Below measuring point [BMP])_______________________
Height of screened or uncased section of well (L_e)____________________

Static Depth of Water (BMP)_____________________________________
Depth of Suction Line (BMP)_____________________________________

Time	Depth to Water	Drawdown	Remarks

Page _____ of_____

Job No. ____________

Job Name ____________

By ____________

Date ____________

Well Identification______________________ Test No.________________

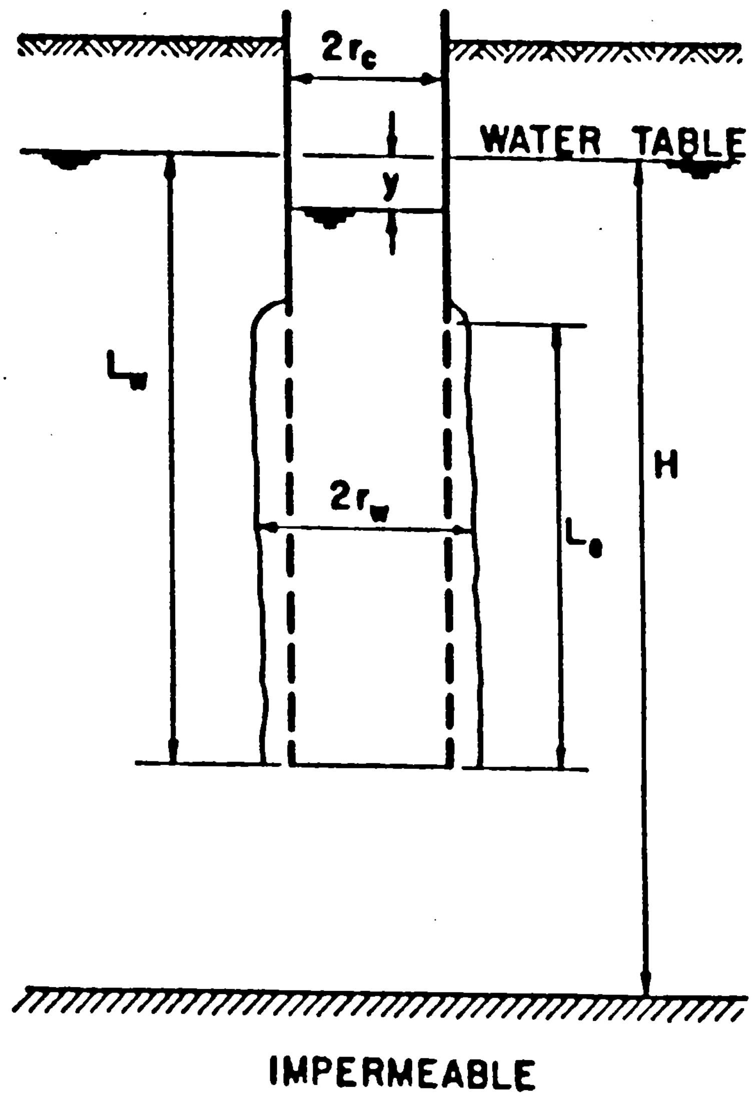
Time	Depth to Water	Drawdown	Remarks

Job No. ____________
Job Name ____________
By ____________
Date ____________

EXHIBIT B

GEOMETRIC FACTORS FOR RISING HEAD SLUG TEST ANALYSIS

Well Identification ____________



(See Bouwer, 1978, Appendix A for explanation of symbols)

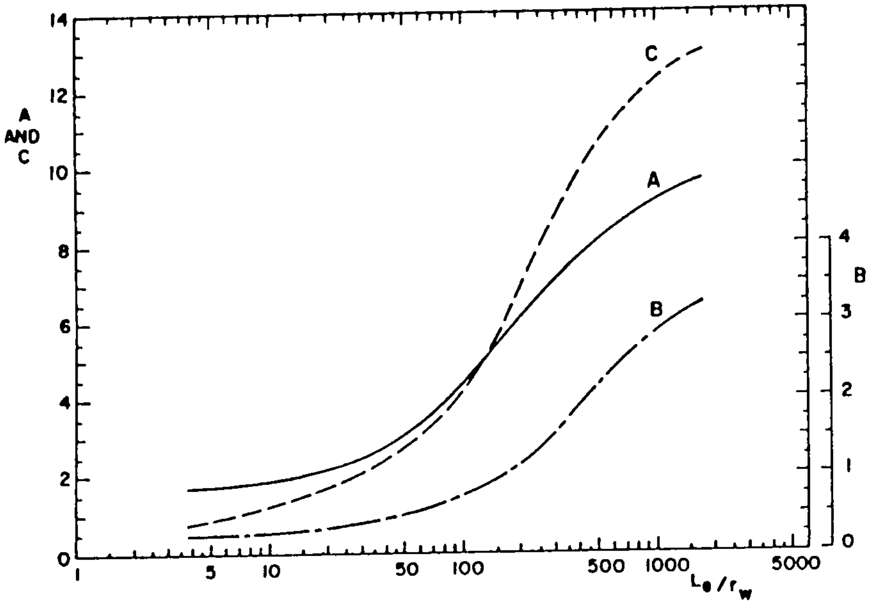


Figure 5.11 Curves relating coefficients A, B, and C to L_e/r_w.

aquifer), the term $\ln [(H - L_w)/r_w]$ in Eq. (5.42) cannot be used. For this situation, the equation for $\ln (R_e/r_w)$ is

$$\ln \frac{R_e}{r_w} = \frac{1}{\dfrac{1.1}{\ln (L_w/r_w)} + \dfrac{C}{(L_e/r_w)}} \tag{5.43}$$

where C is a dimensionless coefficient shown in Figure 5.11 as a function of L_e/r_w. The value of $\ln (R_e/r_w)$ calculated with Eqs. (5.42) and (5.43) is within 10 percent of the analog value if $L_e > 0.4L_w$ and within 25 percent if $L_e < 0.2L_w$.

Since K, r_c, R_e, r_w, and L_e are constant for a given well, $1/t \ln (y_0/y_t)$ must also be constant, as indicated by Eq. (5.41). Thus, when the observed values of y are plotted against t on semilogarithmic paper (y on the log scale), the data points should form a straight line. This is exemplified in Figure 5.12, showing data from a slug test on a well in the Salt River bed west of Phoenix, Arizona (see Problem 5.7). The data begin to deviate from a straight line at small y, probably because of measurement error. The straight-line portion of the points should be used to evaluate $1/t \ln (y_0/y_t)$ for calculation of K.

The time $t_{90\%}$, necessary for the water level in the well to rise 90 percent of the distance back to the equilibrium level, is given by the equation (Bouwer and Rice, 1976)

$$t_{90\%} = 0.0527 \frac{r_c^2}{K T} \ln \frac{R_e}{r} \tag{5.44}$$

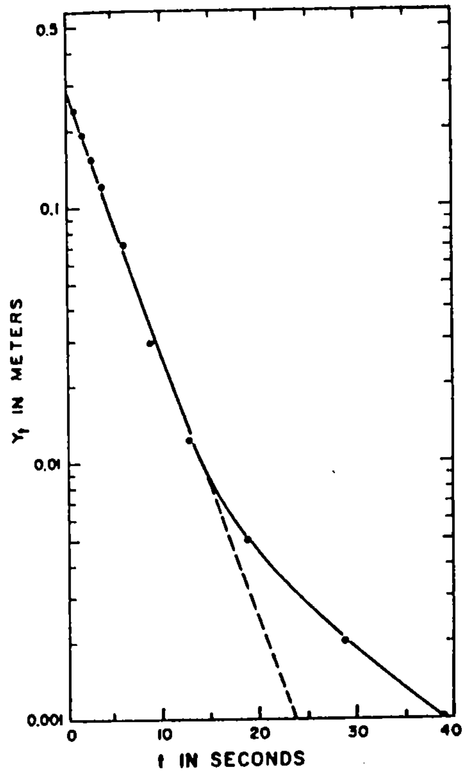


Figure 5.12 Plot of y versus t for slug test on East Well.

If K and/or L_e are relatively large, $t_{90\%}$ may be only a few seconds. Such fast water-level rises can be measured with sensitive pressure transducers and fast strip-chart recorders or x-vs.-y plotters to record the transducer output.

Although streamlines in flow systems around slug-tested wells contain both vertical and horizontal portions, most of the head loss is dissipated in a horizontal direction (Bouwer and Rice, 1976). Thus, K yielded by the slug test primarily reflects K in horizontal direction. The portion of the aquifer on which K is measured is approximately a cylinder with a radius of about R_e and a height slightly larger than L_e. The T value of the aquifer is obtained by multiplying K by H, assuming of course that the aquifer is uniform.

Since the water table in the aquifer was held at a constant level and taken as a plane source of water in the analog evaluations of R_e, the slug test of Bouwer and Rice can also be used to estimate K of confined aquifers that receive most of their water from the upper confining layer, through leakage or compression.

5.3.1 Slug Test

Cooper et al. (1967) obtained a solution of Eq. (4.21) to calculate T and S of confined aquifers from the rate of rise of the water level in a fully penetrating well after a sudden removal of a slug of water. Type curves were prepared so that T and S could be evaluated by matching field data with type curves, similar to the Theis procedure for pumping tests. The S value obtained with this technique may not be reliable because the shape of the type curves is rather insensitive to S (Lohman, 1972).

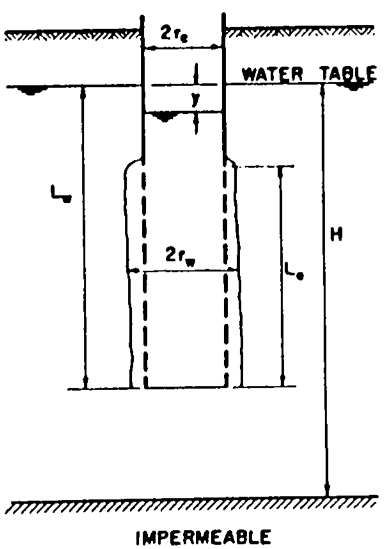


Figure 5.10 Geometry and symbols of partially penetrating, partially perforated well in unconfined aquifer with gravel pack or developed zone around perforated section.

A slug-test procedure applicable to fully or partially penetrating wells in unconfined aquifers was developed by Bouwer and Rice (1976). The procedure is based on the Thiem equation (4.3) and assumes negligible drawdown of the water table around the well and no flow above the water table. The term $h_2 - h_1$ in Eq. (4.3) then represents the distance y of the water level in the well below the water table (Figure 5.10). The rate of rise dy/dt of the water level after removal of water is expressed as

$$\frac{dy}{dt} = -\frac{Q}{\pi r_c^2} \tag{5.40}$$

where r_c is the radius of the well section where the water level is rising and Q is the flow of groundwater into the well. The minus sign in Eq. (5.40) is introduced because y decreases with increasing t, so that dy/dt is negative. Substituting the Thiem equation (4.3) for Q in Eq. (5.40), integrating, and solving for K yields

$$K = \frac{r_c^2 \ln (R_e/r_w)}{2L_e} \frac{1}{t} \ln \frac{y_0}{y_t} \tag{5.41}$$

where R_e = effective radial distance over which the head difference y is dissipated
r_w = radial distance between well center and undisturbed aquifer (r_c plus thickness of gravel envelope or developed zone outside casing)
L_e = height of perforated, screened, uncased, or otherwise open section of well through which groundwater enters
y_0 = y at time zero
y_t = y at time t
t = time since y_0

The effective radius R_e is essentially the effective value of r_2 to be used in Eq. (4.3) so that it gives the correct value of Q (the Thiem equation was developed for horizontal flow only and as such cannot be used to calculate Q for the system of Figure 5.10). Values of R_e were experimentally determined with a resistance network analog for different values of r_w, L_e, L_w and H (see Figure 5.10 for meaning of symbols). The following empirical equation was then developed to relate R_e to the geometry and boundary conditions of the system

$$\ln \frac{R_e}{r_w} = \frac{1}{\dfrac{1.1}{\ln (L_w/r_w)} + \dfrac{A + B \ln [(H - L_w)/r_w]}{(L_e/r_w)}} \tag{5.42}$$

where A and B are dimensionless parameters shown in Figure 5.11 in relation to L_e/r_w. If H is much larger than L_w, a further increase in H has little effect on the flow system and, hence, on R_e. The analog analyses indicated that the effective upper limit of $\ln [(H - L_w)/r_w]$ is 6. Thus, if $H - L_w$ is so large that $\ln [(H - L_w)/r_w] > 6$, a value of 6 should still be used for this term in Eq. (5.42), including the theoretical case of $H = \infty$. If $H = L_w$ (well penetrating to bottom of

Golder Associates

Technical Procedure

Number: TP-1.2-18
Title: SAMPLING SURFACE SOIL FOR CHEMICAL ANALYSIS

Prepared by	Approved by	Approved by	Effective Date	Rev. Level
[illegible] 9/4/96	[illegible] 9/4/96	[illegible] 9-4-96	9-12-96	-5-

UNCONTROLLED COPY
The hard copy of this document is not controlled and may be obsolete.
Verify current revision level prior to use.

Golder Associates

Technical Procedure

Number: TP-1.2-18
Title: SAMPLING SURFACE SOIL FOR CHEMICAL ANALYSIS

Prepared by	Approved by	Approved by	Effective Date	Rev. Level
[signature] 9/4/96	[signature] 9/4/96	[signature] 9-4-96	9-12-96	-5-

1. PURPOSE

This technical procedure establishes uniform methods for sampling surface soils for chemical analysis.

2. APPLICABILITY

This Technical Procedure shall be used by all Golder Associates Inc. (Golder) personnel sampling surface soils for chemical analysis.

3. DEFINITIONS

3.1 Surface Soil

Surface soil is defined as consolidated soil on the land surface or as exposed by an excavation or boring within twenty (20) feet of the land surface.

3.2 Sampling Interval

The sampling interval is defined as the stratigraphic depth represented by the soil sample.

3.3 In Situ Soils

The term in-situ soils refers to soils as they occur in place within the soil column.

4. REFERENCES

Golder Associates Technical Procedure TP-1.2-23, "Chain of Custody."

Golder Associates Technical Procedure TP-1.1-2, "Geodetic Surveys."

5. DISCUSSION

None

6. RESPONSIBILITIES

6.1 Sampling Technician

The Sampling Technician is responsible for completing the sampling assignment in accordance with this Technical Procedure and governing project plans or instructions.

6.2 Task Leader

The Task Leader is responsible, within the guidelines of governing plans or instructions, for determining which soils shall be sampled and for monitoring the sampling process to ensure that procedures and documentation are in accordance with this document.

6.3 Project Manager

The Project Manager or a qualified designee is responsible for determining the type of chemical analyses to be performed on soil samples, and for defining such requirements to project staff through appropriate plans or instructions.

7. EQUIPMENT AND MATERIALS

- Brunton compass, 0° to 360° divisions;
- site map and clipboard;
- bound field logbook or field report forms (Exhibit A);
- assorted standard field equipment (e.g., hammers, post-hole digger, shovel, hand auger) for exposing soils to be sampled;
- measuring tape;
- engineer's rule (six feet long, with 0.10 foot graduations);
- indelible ink pens;
- two-inch wood stakes and colored flagging material;
- if required, sampling equipment appropriate for soils to be analyzed for non-volatile constituents; all such equipment shall be metal (steel, stainless steel or aluminum) and may include hand augers, hand scoops, sampling thiefs, sampling dredges, core samplers, or sampling triers. If volatile constituents are to be analyzed in the soil samples, sampling equipment shall be designed to minimize exposure to the atmosphere. As an example, a metal drive tube appropriate for the size of the soil particles and slightly smaller in diameter than the wide-mouth glass sample bottles may be used, with appropriate sample extraction accessories;
- sample bottles, sized appropriately for the desired sample and soil particle size;
- Chain of Custody records, seals, and sample labels as required by procedure TP-1.2-23, "Chain of Custody";
- appropriate decontamination solutions such as organic free distilled/deionized water, non-phosphate detergent, tap water;
- decontamination equipment such as brushes and sprayers, and drums or applicable plan or containers for capturing decontamination waste solution; and

- thermometer controlled in accordance with Golder's quality procedure for calibration of measuring and test equipment.

8. PROCEDURE

8.1 Sample Location

Location mapping shall be to the level of detail required by the applicable plan or instructions, and sound engineering and geologic practice. If the base map for the sampling site is of sufficient accuracy, the sample location may be approximated within a 10' radius and physically identified by a wood stake marker. If the base map does not have the required accuracy, locations shall be described by either (1) tape measurement from three permanent features identifiable on the base map; (2) measured along a compass bearing from a permanent feature; or (3) triangulated with compass bearings from three permanent features identifiable on the base map. Compasses may be used only when the site does not contain magnetic or large metal objects. The locations so derived will be identified by a wood stake marker with test pit designation, and recorded as described in Section 8.2. When required by project directive, all location markers will be geodetically surveyed in accordance with TP-1.1-2, "Geodetic Surveys."

8.2 Documentation

Final sample location, sample types and numbers, and relevant sampling events (including on-site personnel and all visitors) shall be recorded on Field Report forms (Exhibit A) or bound field logbooks. Events shall be recorded chronologically, with the time of each event noted.

8.3 Decontamination

All sampling equipment shall be decontaminated prior to the start of sampling activities and between each use. Unless other decontamination procedures are specified in the project plans or instructions, the following steps will be followed. The sampling equipment shall be washed with non-phosphate detergent solution. Brushes shall be used to aid in removing all visible soil or grit. A tap water rinse shall be used to thoroughly remove all detergent solution. The final rinse shall be with organic free distilled/deionized water. All waste wash solutions shall be captured and disposed of in the manner defined by the applicable project plan or instruction, in compliance with applicable regulatory requirements.

8.4 Sampling

The soils to be sampled shall be exposed prior to sample acquisition. If the upper six inches of soils are to be sampled, then surface vegetation shall be removed. If samples are to represent discrete depth intervals below land surface, then overlying soils shall be removed by a shovel, post-hole digger, hand auger, or other appropriate method to the desired interval. For loose watery sediments from stream bottoms, a pond sampler, sampling dredge, pail, or ladle can be used. The sediment sample should be allowed to settle and the extra water decanted prior to transferring samples to containers. For cohesive wet or dry stream-bottom samples, a vertical-pipe, sampling dredge, or core sampler can be used and driven into the stream bed to the selected depth. An in-situ soil sample shall be obtained from the desired sampling interval. If the required analyses do not include volatile constituents, an in-situ soil sample can be obtained using a hand scoop, hand auger, sampling thief, or sampling trier. The soils shall be visually inspected and immediately put into the appropriate sample bottle as required by the governing project plan or instruction. No preservatives shall be added to the sample.

If soils are to be analyzed for volatile constituents, the sample shall be obtained from the desired interval using a drive tube sampler. Contact between the atmosphere and the sample must be minimized; the drive tube sampler shall be driven into the materials with a hammer, and the sample extruded directly into the appropriate sample bottle. An air-tight cap shall be immediately placed on the sample bottle; no preservatives shall be added.

If a backhoe is used to expose sampling intervals for analysis of volatile constituents, a hand auger or drive tube may be used to sample the test pit walls or floor when the test pit is less than four (4) feet deep. If the test pit is greater than four (4) feet, a relatively undisturbed sample may be obtained from the backhoe bucket using a drive tube sampler.

8.5 Composite Samples

If soil sample composites are to be established, equal volumes of individual samples shall be added together for the composite sample. At least three small, equal sized samples from several points within a five foot radius shall be collected. Samples will be placed into a clean, decontaminated stainless steel container and each portion will be stirred together into one composite. The composite sample shall be given an individual sample number, and the sample number of each contributing sample recorded in the field logbook or Field Report form.

8.6 Sample Labeling, Handling, and Shipment

Samples shall be immediately labeled, sealed with a tamper-proof seal and relevant data recorded on individual Chain of Custody forms as required by TP-1.2-23, "Chain of Custody." Samples shall be placed in a chilled cooler at approximately 4° C, ± 2°C, as soon as possible. A thermometer shall be placed in the cooler for temperature monitoring purposes. The cooler shall remain in sight of the Sampling Technician at all times, or be kept in locked storage, as required by TP-1.2-23.

Samples shall be forwarded to the analytical laboratory accompanied by the Chain of Custody record, in compliance with TP-1.2-23 requirements. When samples are ready for shipment, the Task Leader shall release the sample to the carrier, who shall also sign the custody form. The Chain of Custody form is in triplicate. One copy of the form shall be retained by the Task Leader; the original form and the remaining copy shall be shipped with the sample. Upon receipt at the laboratory, the laboratory custodian shall verify the integrity and identification of the sample, sign the form, and return the original copy to the Task Leader or Project Manager. All originals shall be retained in the project records.

8.7 Site Restoration

Any excavation or hole made to obtain samples shall be backfilled with the excess material removed from the hole, unless other requirements are invoked by governing plans or instructions.

8.8 Field Change Request

Variation from established procedure requirements may be necessary due to unique circumstances encountered on individual projects. All variations from established procedures shall be documented on a Field Change Request form (Exhibit B) and reviewed by the Project Manager and the QA Manager.

The Project Manager may authorize individual Field Engineers to initiate variations as necessary. If practical, the request for variation shall be reviewed by the Project Manager and the QA Manager prior to implementation. If prior review is not possible, the variation may be implemented immediately at the direction of the Field Engineer, provided that the Project Manager is notified of the variation within 24 hours of implementation, and the Field Change Request is forwarded to the Project Manager and QA Manager for review within 2 working days of implementation. If the variation is unacceptable to either reviewer, the activity shall be reperformed or action shall be taken as indicated in the Comments section of the Field Change Request form.

All completed Field Change Request forms shall be maintained in the project records.

TP1'2'18.RV5

GOLDER ASSOCIATES
4104 148th Avenue NE
Redmond, Washington 98052

(206) 883-0777

DATE	JOB NO
PROJECT	
LOCATION	
CONTRACTOR	OWNER
WEATHER	TEMP °at AM °at PM
PRESENT AT SITE	

TO ______________________

____

____

THE FOLLOWING WAS NOTED:

COPIES TO ______________________

____

FIELD REPORT

SIGNED ______________________

EXHIBIT **A**
FIELD REPORT
TP 1.2-18

PROJECT NO. IP3 1024   DRAWING NO. 48020   DATE 1/18/94   DRAWN BY TK

Golder Associates

FIELD CHANGE REQUEST

Golder Associates

Job/Task Number: ______

Other Affected Documents: ______

Requested Change: ______

Reason for Change: ______

Change Requested by: ______ Date ______

Reviewed by: ______ Date ______
GAI Project Manager

Comments: ______

Reviewed by: ______ Date ______
GAI QA Manager

Comments: ______

IP3 1024/65946

Golder Associates Inc.

EXHIBIT B
FIELD CHANGE REQUEST FORM
TP-1.2-18

Golder Associates

Technical Procedure

Number: TP-1.3-1, Revision 2

Title: GEOLOGIC MAPPING OF SOILS EXPOSED IN TEST PITS

Prepared by	Approved by	Approved by	Effective Date	Rev. Level
[signature] 1/3/97	[signature] 1/8/97	[signature] 1-9-97	1-10-97	-2-

TP-1.3-1

Rev. 2

RECORD OF REVISION

Section	Description of Revision
All	New format throughout
1.	Editorial changes
7.	Added introduction sentence
8.2	Editorial changes to first sentence Deleted reference to TP-1.1-2, "Vertical and Horizontal Geodetic Survey"
8.3	Changed excavation depth to 4 feet
8.9 & Exhibit C	Added section and form for Field Change Requests

1. PURPOSE

This Technical Procedure establishes uniform methods of observation, identification, and recording of data observed in vertical excavations completed for the investigation of soils.

2. APPLICABILITY

This Technical Procedure is applicable to persons or parties engaged in the mapping of vertical shafts or test pits for soils investigations.

3. DEFINITIONS

3.1 Vertical Shaft

A supported excavation advanced in a vertical orientation, the purpose of which is to penetrate, examine, and test foundation soils in situ.

3.2 Test Pit

A supported or non-supported depth dependent excavation, the purpose of which is to penetrate, examine, sample and test surficial soils in situ.

3.3 Test Pit Mapping

Mapping accomplished by observing, identifying, and recording geologic information exposed in the walls of excavated test pits.

4. REFERENCES

4.1 Golder Associates Technical Procedure TP-1.2-6, "Field Identification of Soil."

5. DISCUSSION

5.1 None

6. RESPONSIBILITY

6.1 Geologist/Field Engineer

Responsible for completing the assigned mapping investigation.

6.2 Task Leader

Responsible for making periodic observations to determine effective and correct implementation of the shaft/test pit mapping program.

7. EQUIPMENT AND MATERIAL

Supplies required for Golder Associates field personnel generally include the following:

- Brunton compass, 0^0 to 360^0 divisions
- Base/site map and map board
- 35mm camera and film
- Field notebook or appropriate Field Report Forms (Exhibit A)
- Assorted standard field equipment (i.e., rock hammer, scales, wood stake markers, etc.)
- Measuring tape
- Engineers rule (6-feet long, with 0.10-foot graduations)
- Field Test Pit Log Forms (Exhibit B)
- Other equipment or material necessary to complete a specific task as determined by the task leader.
- Indelible ink pens.

8. PROCEDURE

8.1 General Considerations

Mapping activities shall be thorough, accurate, and shall follow sound engineering and geologic practice.

8.2 Location Mapping

Location mapping shall be to the level required and in accordance with accepted engineering and geologic practice. If the base map is of sufficient accuracy, the test pit location may be approximated within a 10' radius and physically identified by a wood stake marker. If the base map does not have the required accuracy, locations shall be described by either (1) tape measurement from three permanent features identifiable on the base map; (2) measured along a compass bearing from a permanent feature; or (3) triangulated with compass bearings from three permanent features identifiable on the base map. Compasses may be used only when the site does not contain magnetic or large metal objects. The locations so derived will be identified by a wood stake marker with test pit designation.

8.3 Test Pit Mapping

Test pit mapping shall be accomplished by the Golder Geologist/Engineer when the test pit has been advanced to a safe depth as determined by the Golder geologist/engineer or the maximum test pit depth. The Golder geologist/engineer shall not enter an excavation that is deeper than 4 feet unless (1) the sidewalls of the excavation are supported, or (2) the sidewalls have been appropriately sloped or benched.

8.4 Field Test Pit Log

The test pit stratigraphy, depth (measure from ground surface) of each strata, pit orientation, discernible structure and moisture (if discernible) will be recorded by the Golder geologist/engineer on the Field Test Pit Log (See Exhibit B). Any other observed data on the nature of the material present in the sidewalls of the excavation, such as cementation, contamination, fill debris, etc. will also be recorded on the Field Test Pit Log.

8.5 Structural Data

Structural data shall be recorded by azimuth to true north or by quadrants.

8.6 Photographic Record

35-mm color slides shall be taken of each test pit and important structural or stratigraphic features. A suitable reference object shall be placed in the field of view for scale. Photographs shall be described in the field notebook or appropriate Field Report Form and referenced on the Field Test Pit Log by the film roll number, and exposure number.

8.7 Field Reports

Field reports shall be produced in triplicate and the originals forwarded on a daily basis to the Project Document Custodian.

8.8 Test Pit Abandonment

All excavated materials shall be backfilled into the test pit and compacted with the backhoe bucket to an acceptably safe level as determined by the Golder Geologist/Engineer. The approximate center of the backfilled pit will be marked with a wood stake with test pit designation if further ground control will be required.

8.9 Field Change Request

Variation from established procedure requirements may be necessary due to unique circumstances encountered on individual projects. All variations from established procedures shall be documented on Field Change Request (Exhibit C) and reviewed by the Project Manager and the QA Manager.

The Project Manager may authorize individual Geologist/Engineers to initiate variations as necessary. If practical, the request for variation shall be reviewed by the Project Manager and the QA Manager prior to implementation. If prior review is not possible, the variation may be implemented immediately at the direction of the Geologist/Engineers, provided that the Project Manager is notified of the variation within 24 hours of implementation, and the Field Change Request is forwarded to the Project Manager and QA Manager for review within 2 working days of implementation. If the variation is unacceptable to either reviewer, the activity shall be reperformed or action shall be taken as indicated in the Comments section of the Field Change Request form.

All completed Field Change Request forms shall be maintained in project records.

s:\qa\ip3-1024\1129tt1.tp

GOLDER ASSOCIATES
4104 148th Avenue NE
Redmond, Washington 98052

(206) 883-0777

DATE	JOB NO.
PROJECT	
LOCATION	
CONTRACTOR	OWNER
WEATHER	TEMP. ° at AM ° at PM
PRESENT AT SITE	

TO ______________________

THE FOLLOWING WAS NOTED:

COPIES TO ______________________

FIELD REPORT

SIGNED ______________________

EXHIBIT **A**
FIELD REPORT
TP-1.3-1

Golder Associates

FIELD TEST PIT LOG

Temp. ________ Weather ______________________ Engineer ____________ Operator ________ Test Pit ________

Equipment ______________________________ Contractor ______________________ Date ________

Location ______________________________ Elevation ____________ Datum ________ Job ________

W ← → E

0 5 10 15 20

0
5
10
15
20

Samples	
No	Depth

Sample Descriptions and Excavation Notes	Time	Depth of Hole	Depth to W/L

Special Notes

EXHIBIT B

FIELD TEST PIT LOG

TP-1.3-1

PROJECT NO. IP3 1024 DRAWING NO. 63275 DATE 12/8/95 DRAWN BY EA

FIELD CHANGE REQUEST

Golder Associates

Job/Task Number: ______

Other Affected Documents: ______

Requested Change: ______

Reason for Change: ______

Change Requested by: ______ Date ______

Reviewed by: ______ Date ______
GAI Project Manager

Comments: ______

Reviewed by: ______ Date ______
GAI QA Manager

Comments: ______

EXHIBIT **C**
FIELD CHANGE REQUEST FORM
TP-1.3-1

TECHNICAL GUIDELINE FOR
MONITORING WELL DRILLING AND INSTALLATION
TG-1.2-12

Rev. #8
8/20/2009

Table of Contents

List of Exhibits

List of Figures

1.0 PURPOSE

This document establishes uniform guidelines for the selection of materials and installation of monitoring wells or piezometers in unconsolidated and consolidated deposits.

2.0 APPLICABILITY

This technical guideline is applicable to all field personnel involved with the design and installation and abandonment of groundwater monitoring wells and piezometers. This document should be read in conjunction with any and all regulatory, workplan, order, client specific, or other project-specific guidelines.

3.0 DEFINITIONS

3.1. Monitoring Wells / Piezometers

A monitoring well is a well completed within a specific zone of interest, of sufficient diameter and construction to allow sampling and/or pump testing. A piezometer is typically a smaller diameter than a monitoring well, and is screened within a specific zone of interest, of sufficient diameter and construction to allow potentiometric measurements.

3.2. Bentonite

Bentonite is an expanding sodium bentonite clay used to seal the annular space between the production casing and the wall of the borehole. Calcium bentonite may be more appropriate in calcium-rich environments due to reduced cation exchange potential. Bentonite is also added to drilling circulation fluid on "mud" rotary rings to increase fluid viscosity and to transport drill cuttings to the surface more effectively. Additional information is provided in sections 7.2.6 through 7.2.10 and 7.2.13.

3.3. Casing, or "Drive" Casing

Drive casing is a pipe used to line a borehole to prohibit caving and/or prevent direct flow from the formation into the borehole. Hollow stem augers may be considered as analogous in function to drive casing for the purposes of this Technical Guideline.

3.4. Grout

Grout is a cement and/or bentonite mixture, originally fluid enough to be pumped through pipes, and used to seal casing within a borehole. Specifications are given in Section 7.2.6 and 7.2.7 below.

3.5. Well Screen

A well screen is a manufactured "wire"-wrapped, slotted or otherwise porous pipe which allows the flow of water from the formation into the well. Additional information is provided in section 7.2.1.

3.6. Monitoring Interval

The monitoring interval is the only zone in which groundwater can enter the well.

3.7. Centralizers

Centralizers are “basket-like” frames typically made of stainless steel that attach to the exterior of the casing, and whose radial metal bands keep the casing centralized in the borehole. Additional information is provided in section 7.2.2.

3.8. Riser Pipe

Riser pipe extends from the top of the screened interval to a short distance above ground surface (typically 2-3 feet).

3.9. Filter Pack/Sand Pack

Filter Pack/Sand Pack is material (typically granular) that is either placed on the exterior of the screen before installation, or pumped into the annulus between the screen and borehole wall after installation. Filter Pack/Sand Pack protects the screen, prevents clogging, and enhances flow into the well.

4.0 DISCUSSION

In order to generate quality data using these guidelines, it is incumbent on the field personnel to have reviewed these and other appropriate guidelines. This document should also be read in conjunction with any and all regulatory requirements, site-specific work plans, administrative orders, and client- specific or other project-specific procedures.

5.0 RESPONSIBILITIES

5.1. Field Supervisors

Field Supervisors are responsible for overseeing well installation in compliance with all project specific guidelines. The Field Supervisors are responsible for ensuring that the drilling contractors complete and submit all requirements (permit applications, well installation reports, etc.) before and after well installation. They must review and approve daily work reports and/or notes, and they must maintain daily borehole logs, well construction forms, etc.

5.2. Project Manager

The Project Manager shall be responsible for:

- Selecting location of the boreholes at the site and determining depth and the various design details of the monitoring well completion;
- Selection and contracting of services of drilling subcontractors;
- Scheduling;
- Assurance that appropriate equipment and materials are available to accomplish the task;
- Providing guidelines or specific work instructions for technical requirements beyond the scope of the applicable technical guidelines;
- The completion of drilling operations and well installations to the satisfaction of Golder's standards of operation and the clients' requirements; and
- Preparation of all reports and project deliverables.

5.3. Project Director/Principal-In-Charge

The Project Director shall be responsible for agreeing on design details outside the scope of this document and overall quality of project deliverables.

6.0 EQUIPMENT AND MATERIALS

6.1. Drilling Equipment

The following equipment may be used on most well drilling and installation jobs:

- A suitable drill rig (usually auger, cable tool, rotary, or direct push) with all equipment and accessories required for completing the job. The drill rig should be examined to determine the general condition, how well it has been maintained, and the general cleanliness of the drill rig and equipment. The drilling equipment should be relatively free of at least mineral oils, grease, hydraulic fluids, drilling mud, etc. Rig condition and corrective actions must be documented in the field log;
- A steam cleaner for cleaning drilling equipment between holes with associated wash rinse solutions (e.g., alkonox), storage tanks, brushes, and other equipment as necessary to capture and contain decontamination solutions;
- Additional equipment that may be required for drilling such as water trucks, drive casing, booster compressors, mud pumps, appropriate bits and sampling equipment (if required), additional support vehicles and equipment, etc.;
- Sampling equipment (core barrels, split-spoons, drive tubes, etc.) if needed; and
- A grout pump, mixer, and suitable clean tremie pipe, line, or pressure-grout system.

6.2. Field Engineering Equipment and Logs

The following equipment is suggested for documenting the construction of groundwater monitoring wells:

- Clipboard;
- Indelible ink pens and pencils;
- Engineering tape measure with 0.01 foot or, for some jobs, metric increments;
- Weighted engineering tape for sounding well material depth. The length of tape should be suitable for total anticipated well depth (check the accuracy of the weighted tape);
- Electric water level measuring tape suitable for total anticipated depth of borehole;
- Interface probe suitable for total anticipated depth of borehole;
- Color charts for soil comparison;
- 10% hydrochloric acid solution for calcareous deposits;
- Suitable containers for collecting samples of well construction materials;
- Sample containers for soil samples;
- Sample containers, cooler, etc. for chemical laboratory samples;

- Field Notebooks;
- History of Hole forms (Exhibit A);
- Borehole Log forms (Exhibit B);
- Monitoring Well Construction Forms (Exhibit C);
- Field Change Request (Exhibit D);
- Well development instrumentation, multi-parameter meter and calibration standards (meter should be capable of measuring pH, specific conductance, redox, dissolved oxygen and temperature);
- Turbidity meter and calibration standards; and
- Flow-through cell for collection of field measurements.

6.3. Health and Safety Equipment

All required equipment as shown by the Health and Safety Plan:

- Fire Extinguisher;
- First Aid Kit;
- Hard hat while drilling or near a drill rig- or pump truck;
- Steel-toed, and possibly steel-shanked, chemical resistant, or leather, or rubber boots;
- Suitable clothing that could include long sleeve shirts, long pants, etc.;
- Tyvek, other protective clothing, and respiratory protection devices as required by applicable site health and safety plans;
- Protective eyewear;
- Monitoring equipment as required by applicable health and safety plans; and
- Hearing protection while drilling or near a drill rig or pump truck.

7.0 PROCEDURE

7.1. Regulatory Considerations

In most states, both monitoring well and piezometer installation and their abandonment is specifically regulated by local, state, or regional regulations, laws and guidelines that pertain to the drilling, installation and abandonment of monitoring wells. In addition there may be client specific requirements. All such client and regulatory requirements must be reviewed before designing, drilling, and installing monitoring wells or piezometers. At a minimum, the following actions must be taken:

- Initiate start cards, permits, or other documents, certifications, and fees that may be required to drill and install monitoring wells or piezometers;
- Ensure that monitoring wells and piezometers will be drilled, installed and abandoned by an entity that meets all requirements (e.g., licenses) for conducting operations in that particular location;

- Initiate utility location process and document the location of all utilities before drilling, including both underground and overhead utilities. Check local codes for safety equipment (i.e., traffic codes, fire codes, etc.) required around drill rig during operation within city limits. Check that additional permits such as excavation or cultural reviews are not required, and be sure that overhead utilities will not interfere with the standing drilling rig; and
- Ensure that all follow up well or piezometer installation and abandonment reports required by appropriate agencies are completed by the drilling subcontractor and/or Golder and submitted. Obtain copies of all well and piezometer reports submitted by subcontractor for project files.

7.2. Materials

7.2.1. Well Screen

The well screen shall normally consist of machine slotted or “wire” wrapped, schedule 40 or 80 (ASTM-D1785) PVC pipe with flush joint threads. Both slotted and “wire” wrapped schedule 40 PVC are typically available at short notice. The use of other materials such as stainless steel or porous organic polymers may be required for certain situations where PVC may be reactive, may inhibit the collection of representative groundwater samples, may allow excess siltation, or may not be mechanically strong enough for a particular application. Use of alternative materials shall be specified by the Project Manager or by site-, regulatory-, or client- specific work documents.

Minimum requirements are identified below:

- A flush threaded bottom plug shall be installed securely in order to withstand all installation and development pressures without becoming damaged or dislodged, assuming (as is true in most cases) that the internal to be screened is at the bottom of the borehole.
- As a general rule, screen length should be the minimum necessary to achieve the objective for monitoring. The lengths of screens shall be determined by the Project Manager based on the site hydrogeology and other project-specific requirements. Screened interval, at or near the water table, will often be 5 to 20 feet in length (taking into account any annual fluctuations in the water table – particularly if monitoring for light non-aqueous phase liquids). Wells completed at depth below the water table will usually be completed with a 3-, 5-, or 10-foot screen.
- All flush joint threads shall be sealed with any specified and supplied manufactured o-ring seals; Teflon tape shall be applied to the male threaded ends if the pipe is not equipped with o-rings. Riveted, screwed or glued joints shall not be permitted without agreement of the Project Director.
- The slot size will typically be 0.010 or in some cases 0.020-inches. The slot size shall be specified by the Project Manager and be determined relative to the formation particle size and the filter pack grain size. The use of a 0.006 or 0.008 slot size, or porous polymer screen should be considered in all cases where low turbidity is required and a properly designed sand-pack cannot be calculated for use with a 0.010 slot size.
- The screens shall typically have been factory cleaned to remove all oils, greases, solvents, waxes, etc. used in the manufacturing process and shall be individually wrapped and sealed or collectively stored and sealed in boxes from the factory.

7.2.2. Centralizers (Optional)

If required by the Project Manger or project work plans, friction or bolt-on style centralizers of appropriate material (typically stainless steel) shall be used. Deeper monitoring wells (i.e., >50’ depth) will usually benefit from centralizers if the well is installed in a borehole several times the diameter of the pipe and screen. Centralizers are typically not required for installing monitoring wells through auger flights.

7.2.3. Riser Pipe

The riser pipe shall typically consist of schedule 40 PVC or stainless steel with flush joint threads; the interval between joints shall be five to twenty feet. Minimum typical requirements are itemized below:

- A threaded cap or slip cap shall be provided for the top of the riser.
- All flush joint threads will be sealed with the supplied manufactured o-ring seals; Teflon tape shall be applied to the male threaded ends if the pipe is not equipped with o-rings.
- Riveted or glued joints shall not be permitted unless agreed by the Project Director.
- The riser pipe shall typically have been factory cleaned to remove all oils, greases, solvents, waxes, etc. used in the manufacturing process and shall be individually wrapped and sealed or collectively stored and sealed in boxes from the factory.

7.2.4. Steel Casing

In the event that a well requires permanent steel casing for hole stability or contamination seclusion, the following typical minimum requirements shall apply:

- The minimum inside diameter of steel casing shall be 4 inches in diameter larger than the nominal diameter of the well screen and riser (specific spacing requirements may be required by state regulations).
- The minimum wall thickness of steel casing shall be 0.125 inches; thicker casing may be required by state regulations or good engineering practice.
- The ends of sections of casing shall be threaded or beveled for welding or shall be designed to screw together.
- The casing should be in good condition and not out of round.
- The steel casing should be steam cleaned before use.

7.2.5. Filter Pack/Sand Pack

The filter pack/sand pack shall consist of dry, uniform, and well rounded grains of silica sand. The size of the sand grains will be selected by the Field Supervisor based on the water-bearing aquifer formation characteristics and the size of the screen slots. The sand shall be packaged in sacks typically with polyethylene liners and be clearly labeled as to manufacturer and mesh size of sand.

7.2.6. Cement/Bentonite Grout

Cement/Bentonite grout shall consist of a mixture of Portland Cement with 3-5% bentonite by weight added to help expand the cement on setting, thus providing a tighter seal. No other additives to the cement shall be permitted. Cement shall be Portland Cement Type I or Type II meeting ASTM C 150. The use of Hi Early Type III Cement is prohibited. Bentonite shall be powdered, typically sodium, bentonite furnished in sacks without additives; calcium bentonite may be used in certain calcium-rich environments. Water used during the installation operation for mixing cement/Bentonite grout shall be obtained from a potable source or alternate source of known chemical quality designated by the Field Supervisor.

Cement shall be mixed with water in the proportions of five to six gallons of water per 94-lb sack of cement. Three to five pounds of bentonite powder shall be added to the mix for each sack of cement used. The grout shall be thoroughly mixed with a paddle type mechanical mixer or by circulating the mix through a pump until all lumps are removed. Grout which is lumpy shall be rejected.

7.2.7. Bentonite Grout

Bentonite grout shall be made from a bentonite powder and/or granules for use below the water table. The bentonite grout shall typically have a specific gravity of 2.5, a dry bulk density of 55 lb/ft^3, and a pH of 9 to 10.5. Bentonite grout shall be mixed and used according to manufacturer's specifications and recommendations, and when mixed, will have a thick batter-like consistency. Bentonite shall be powdered or granular (8-20 mesh) sodium bentonite furnished in sacks without additives. Water used during installation operations for mixing bentonite grout shall be obtained from a potable source of known chemical quality identified by the Field Supervisor. The grout shall be thoroughly mixed with a paddle type mechanical mixed or by circulating the mix through a pump until all lumps are removed. Grout which is lumpy shall be rejected.

7.2.8. Volclay

Volclay is a trade name bentonite product that is modified with an initiator to increase the solids and set strength of the grout. The grout remains pumpable up to 2 hours but should be placed as soon after mixing is completed as possible. It sets up after 8-24 hours with final cure 24-72 hours after placement. The normal mix is 2.1 pounds of Volclay to 1 gallon of water. 14.3 pounds of Volclay mixed with 6.7 gallons of water yields 1 cubic foot of grout. A 50-pound bag of Volclay with the 2-pound bag of initiator mixed with about 24 gallons of water makes up about 3.5 cubic feet of grout. Because of potential desiccation and shrinkage, volclay shall only be used for sealing within water-saturated environments.

7.2.9. Pure Gold

Pure Gold is a trade name bentonite product that is an organic-free high-solids bentonite clay grout that has been tested and is certified to be free of contaminants. A 50-pound bag of Pure Gold grout is mixed with 14 gallons of water to yield approximately 2.2 cubic feet of grout. The grout should have density of 10.2 lbs/gal. Because of potential desiccation and shrinkage, pure gold shall only be used for sealing within water-saturated environments.

7.2.10. Bentonite Pellets/Chips

The two- to five- foot seal above the filter sand usually consists of bentonite pellets. Bentonite pellets will usually be a nominal 1/4- or 3/8-in. diameter round, or cylindrical pellets or chips consisting of untreated sodium bentonite, packaged in plastic buckets or plastic lined sacks. Each sack or bucket shall be clearly labeled as to the pellet size. The dry bulk density shall be at least 80 lbs/ft^3. The diameter of the pellets or chips shall be less than one-half the width of the annular space into which they are to be placed. In some cases, and in particular when set in an unsaturated zone, the pellets/chips should be partly hydrated either before placement in the hole or periodically during placement.

7.2.11. Fine Sand Seals

Under certain circumstances when setting the seal in the unsaturated zone, the use of a fine sand seal may replace the bentonite pellet seal. The use of a fine sand seal must be approved by the Project

Manager. The sand used in these cases must be graded as fine (based on the Unified Soil Classification System), and must be a significantly finer grade of sand than used for the sand filter pack.

7.2.12. Concrete

Concrete, when used in monitoring well construction, shall be composed of either pre-mixed, bagged concrete, or a mix of six sacks of cement per cubic yard. Neither additives nor borehole cuttings shall be mixed with the concrete. The concrete pad is not usually steel reinforced. Concrete shall be mixed in accordance with manufacturer's specifications; water must be from an approved source with known chemical quality. The construction of the concrete monument pad/surface seal is shown on Figure 8-2.

7.2.13. Drilling Fluid

Drilling fluid circulates through the drill string, out the bit, and up the annulus to cool the bit and remove cuttings from the hole. Air is circulated on air-rotary rigs, while water or drilling “mud,” usually comprised of a water/bentonite slurry, is used on mud rotary rigs. The viscosity of drilling fluid increases from air to water to “mud” as does its ability to transport cuttings to the surface. The viscosity of bentonite drilling “mud” is dependent upon the concentration of bentonite in the fluid, and is measured with a viscosity funnel.

7.3. Well Borehole Drilling

7.3.1. General Precautions

Water used for mixing cement or bentonite grout or used down hole during drilling should typically be chemically characterized, particularly for the analytes of interest at the site. The Project Manager or Task Leader must approve the water source before use. All bentonite and cement must be pure. Additives either contained in these materials or to be added to the mixture must be approved in writing by the Project Manager. All well screens and well casings should be factory cleaned and sealed or decontaminated prior to use. The seal must not be opened until use. The casing should not be allowed to touch the ground while installing. All down-hole drilling equipment must be decontaminated and cleaned prior to use on a borehole and before being demobilized from the site as noted in Section 7.3.4. below. The decontamination typically includes steam cleaning with a non-phosphate detergent (e.g., Alconox) followed by rinsing with water from an approved potable tap water source. The tap water rinse must be thorough to remove all detergent and grit. All wash solution will be captured and tested prior to disposal. The disposal of decontamination fluids shall be in accordance with the requirements of the appropriate state or federal agency.

7.3.2. Documentation

The Field Supervisor shall be responsible for ensuring that the drilling subcontractor completes and submits any required documentation before and following installation of the well or piezometer, required by regulators. All such records shall be reviewed and approved by the Golder Project Manager prior to submittal and copies of these documents shall be retained for the project files.

The Field supervisor(s) shall be responsible for maintaining a daily borehole log that shall be forwarded to the Task Leader on a daily basis. This log shall be a continuous, chronological log for each borehole/well/piezometer and should include, but not be limited to the following information: Date, well number, drillers name and company, depth and drilling characteristics of each stratigraphic unit drilled, the depth and thickness of each stratigraphic and water bearing zone encountered, any moist zones encountered, the time work starts and stops each day (and the hours spent at each task), time and durations of all shutdowns, depths of collected samples, method of drilling and any problems encountered, size of drill bit used, size, amount and type of any temporary or permanent casing used, amount of water yielded or lost during drilling, type and amount of any drilling additives used, and the type and amount of any lubricants, if any, used on the drilling equipment and the types and quantities of any well construction materials used.

All significant drilling events during the installation of each monitoring well shall be documented daily on a form or in a bound field book. The documentation shall include the time that the events occurred; particular emphasis shall be placed on documenting the production hours and hours delayed in production, with appropriate explanations. Notes on the weather conditions and drilling personnel shall also be recorded. During completion, all backfilled materials and depths of well screens will be sounded with a measuring tape with attached weight on the sounding end. Well completion details shall be recorded on the Monitoring Well Installation Log (Exhibit C) by field staff. All information presented on the Monitoring Well Installation Log shall be recorded, or N/A for Not Available or Not Applicable entered as appropriate.

7.3.3. Initial Equipment Evaluation and Inspection

As soon as possible after the drill rig arrives on site, and certainly prior to beginning the drilling operation or decontamination of the drill rig, inspect and evaluate the drilling equipment supplied by the drilling subcontractor. The equipment should appear to be in good working condition, be maintained properly, and be the proper equipment specified for the job. Lifting cables, fittings, and ropes should be inspected for excessive wear or other signs of weakness. Field personnel should examine the rig for any oil or other fluid leaks that may be hard to detect after the drill rig has been decontaminated. If leaks are detected, discuss them with the subcontractor and arrange for them to be repaired or arrange for other means of containing the leaks around the well site. Inspect all equipment to be used by the subcontractor; this is the time to have arrangements made to get missing equipment to the site.

7.3.4. Decontamination of the Drill Rig and Drill Equipment

The drilling rig and all equipment in contact with soil materials or borehole fluids shall typically be steam cleaned (high pressure at 80 psi and high temperature at +180° F is acceptable) between each borehole. The subcontractor shall normally supply the equipment necessary for this decontamination. Fittings shall be carefully greased or lubed with vegetable oil and fluids carefully added to the drill rig <u>before</u> cleaning. Decontamination shall be conducted at an approved clean location outside the immediate drilling site. Any hazardous materials removed from the equipment must be contained to prevent the spread or release of such materials. Tools and sampling equipment (e.g., split spoon sampler, submersible pumps) to be used for soil sampling or aquifer testing shall generally be decontaminated by steam-cleaning. However, at the Project Manager or Task Leader's direction, the following additional decontamination method may be required: clean by wiping or scrubbing off visible particulate matter; wash with a laboratory-grade non-phosphate detergent (e.g., Alconox), rinse with clean water and isopropyl alcohol; and final rinse with HPLC-grade distilled/deionized water. The detergent, isopropyl alcohol (where necessary), and distilled water will usually be provided by Golder. All other decontamination equipment (e.g., brushes, clean water, buckets, steam cleaner) shall normally be provided by the subcontractor.

7.3.5. Setting up the Drill Rig

Drill rig set up shall be planned with the subcontractor. The prevalent wind direction should be accounted for if the rig will require a preferred orientation for extra cooling or to prevent exhaust from drifting over the decon or sample prep areas. The plan should account for the direction the dust or cuttings will be blown and the direction that will be downwind of the borehole if the borehole is likely to emit volatile organic vapors. The plan should account for the direction in which the water produced during the drilling operations will flow. The drill rig shall be set up by the subcontractor using levels to insure that the borehole is as plumb as possible. The verticality of the kelly or mast should be determined in two directions: side to side and fore and aft. Ensure that the drill rig is adequately blocked below the jacks so that the rig is stable and minimum damage occurs to the land surface. Very fragile surfaces such as a sod yard should typically be protected using sheets of plywood to protect the land surface. Cut a hole in one sheet of plywood the size of the borehole for placing directly over the hole and place other sheets as needed around the site.

Confirm that the rig mast will be clear of all overhead power lines prior to hoisting the mast.

7.3.6. Borehole Size and Drilling Methods

The borehole size will be partly determined by the anticipated drilling requirements to reach the anticipated depth, e.g., will temporary casing need to be driven with the possibility of telescoping casing if refusal is encountered. The borehole size will also be determined by the completion size of the final well production casing/riser pipe and by the state or other regulatory requirements governing the size of the annular space around production and surface casing. The drill hole size and drilling methods will be determined by the Project Manager; methods may be selected from those provided in TG-1.4-5, "Drilling Sampling, and Logging of Soils", or TG-1.2-1, "Rock Core Drilling and Sampling".

7.3.7. Capture of Drill Cuttings and Groundwater

The soil or rock cuttings produced during the drilling operations and any groundwater produced by drilling below the water table may have to be captured if contaminants are anticipated or the site does not allow for the disposal of clean drill cuttings around the drill site. Unless otherwise directed by the Project Manager, the drill cuttings and groundwater should be captured in 55-gallon drums. The borehole number and depths of the cuttings contained in each drum should be noted in permanent paint on the side of the drum and on the lid. The soils and water can then be tested for the presence of the targeted contaminants. If the contaminants are detected, then the drummed cuttings and water must be disposed of in a proper manner as directed by state or other regulatory agencies. It is usually preferred to have the subcontractor move all the 55 gallon drums to a drum storage location that is secure and has been approved by the client/landowner.

Drill cuttings should be monitored continuously for changes in color, lithology, etc. Lothologic variations and the depths they occurred should be recorded on the Monitoring Well Installation Log (Exhibit C).

7.3.8. Verifying the Completed Borehole

Once the borehole has been completed, verify the final depth and determine how clean the borehole is by lowering and retrieving a weighted engineering tape to the total depth of the well. Lower a water level measuring probe down the borehole and record the water level in the borehole following completion of the borehole in compliance with procedure TG-1.4-6, "Water Level Measurement". If non-aqueous phase liquids are found or anticipated, an interface probe should be used to measure the thickness(es) of the non-aqueous liquids. If the borehole is to stand for any period of time before completion of the well, reprobe the borehole to determine the total depth and the water level within the borehole just prior to completion of the well. It is generally a poor practice to allow a borehole to stand open very long if there is the possibility of part of the borehole caving. At the Project Manager's direction, the stratigraphic sequence encountered in the borehole may be verified by geophysical logging. A variety of probes are available for stratigraphic, hydrogeologic and borehole geometry determinations. Geophysical logging equipment will require the same diligence in decontamination to prevent the potential introduction of contaminants into the borehole or well.

7.4. Well Installation

7.4.1. General Requirements

A properly completed well or piezometer should exhibit the following characteristics:

- The only portion of the completed well which will have well screen and a filter-pack/ sand pack should be adjacent to the particular water-bearing zone to be monitored.
- All other sections, except within 5 feet of land surface, should be sealed with a bentonite or cement/bentonite type grout. The liquid slurry grouts will be placed by pumping the grout through a tremie pipe to the appropriate locations, or, if bentonite pellets are used, the pellets will be properly rehydrated and compacted in place. Alternately in certain circumstances, a fine sand seal may be used in lieu of the bentonite seal.
- The uppermost 5 feet or more (or to below frost line) of the borehole annulus will typically be filled with a cement grout for a surface seal, stability in freezing weather, and for supporting protective surface monuments.

See Figure 8-1 for a typical well installation.

7.4.2. Evaluation of the Borehole

Compare the final completed borehole and the stratigraphic log of the samples or cuttings to the anticipated design for the monitoring well. Compare the strata to what was anticipated and verify that the depth is adequate. If the desired monitored interval is above the bottom of the borehole, the borehole must be backfilled with a low permeability grout. The grout shall be tremied slightly below the final depth of the well to the bottom of the borehole and the tremie pipe should be close to the bottom of the hole such that the grout is forced up from the bottom. The auger flights or steel casing shall be pulled or hammered out of the hole in five foot increments. This procedure should be repeated until the bottom of the drive casing or auger flights and top of the grout are equivalent to the bottom elevation of the desired monitoring interval.

The grout should be allowed to set prior to placing the gravel/sand pack and well casing/screen to establish a solid foundation. If bentonite grout does not harden adequately to permit a firm foundation for supporting the well, then a cement/bentonite grout should be used and allowed to harden. **Bentonite and/or cement grout should never be allowed to harden while the drive casing is in contact.** Care must be taken with cement and cement grouts. Cement can alter the pH of the groundwater that it comes in contact with. The best practice is to try and keep cement from being in direct contact with the sandpack of the monitored interval.

7.4.3. Assembly of Well Screen and Riser

The well screen including the bottom plug shall be clean and free of contamination immediately prior to assembly. Take precautions to ensure that grease, oil, or other contaminants do not contact the well screen. All workers handling the well screen shall wear a new pair of cotton or synthetic gloves. The male threaded part of each joint shall be wrapped with Teflon tape if not equipped with o-rings. Joints shall be tightened by hand; however, if necessary, clean pipe or chain wrenches may be utilized if care is exercised not to cut or damage the casing.

7.4.4. Setting the Well Screen and Riser String

The well screen shall be lowered to the predetermined level and held in position by suspending the string of riser pipe or if the string tends to float, by manipulating the hydraulic ram on the drill rig. On deep holes where the weight of the string riser pipe is significantly greater than the flotation force, care shall be taken to keep the riser pipe plumb. The riser shall typically extend above the ground at least three feet, and may be trimmed to the proper length after the grout is in place. If the plumbness of the riser is especially critical or the well is extremely deep, a probe or "dummy" should be lowered down the inside of the riser to verify that the riser is not kinked. The screen and riser string should be suspended from the surface as much as possible during completion, rather than sitting in the borehole, to avoid damaging the screen. At the Project Manager's direction or if required by project work plans, centralizers shall be placed typically at about 20-40 feet apart throughout the riser interval.

7.4.5. Placement of the Filter Pack

The volume of sand required to fill the annular space between the well screen and the wall of the borehole shall be computed by subtracting the volume of the well-screen from the borehole volume of the screened interval and then carefully measured to confirm. The sand pack shall typically extend three to five feet above the uppermost row of slots in the well screen except where limited separation between aquifers occurs (check state regulations). The well screen shall be centered in the well hole and temporary casing by suspending the well screen and riser string and/or using centralizers. At the Project Manager's direction or if required by project work plans, centralizers shall be placed typically at 20-40 feet apart through the screen interval.

While holding the riser pipe with the drill rig, the temporary casing or hollow stem augers shall be carefully withdrawn such that the lowermost point on the casing is exactly at the top of the sand packed portion of the well. This may be accomplished in increments; however, after each increment, a weighted engineering tape shall be inserted and lowered to ascertain that the sand pack has not been raised or lowered during casing withdrawal operation. If necessary the sand pack shall be tamped back into place.

7.4.6. Placement of the Bentonite Seal

A volume of pellets or chips to create a seal typically 3 to 5 feet long should be computed and measured out for introduction into the annular space. The bentonite pellets or chips may be placed by either tremieing the pellets to the required interval or hand pouring the pellets into the annular space at the top of the well. Tremieing of the pellets is usually done on deeper completions or if specifically required in the well completion specifications. **Extreme care must be exercised and the pellets or chips slowly introduced into the annular space to prevent bridging above the level to be completed**. **In addition, the bottom of the casing must be maintained above the uppermost level of the pellets to avoid locking the well casing**. If the bentonite seal is being constructed above the water level in the borehole, exactly five gallons of water per a 5-gallon bucket of pellets or bag of bentonite chips should be slowly poured into the annular space to rehydrate the bentonite. A weighted seal tamper should be lowered down the annulus and used to tamp the pellets or chips into a cohesive mass of clay.

7.4.7. Grouting the Annular Seal

A sample of the final grout shall be collected in a suitable container just prior to ordering the grout injection. The volume of grout, either bentonite or cement/bentonite, required to completely fill the annular space between the seal and the ground surface shall be prepared in the proportions specified in Section 7.2. The volume shall include a quantity to compensate for losses during injection and due to borehole irregularities. All hoses, tubes pipes, water swivels, drill rods, tremie pipes, or other passageways through which the grout will be pumped shall have an inside diameter of at least 0.5 inches.

The grout shall be injected via a side discharge tremie pipe with its opening temporarily set immediately above the bentonite seal. The grout shall be pumped into the tremie pipe continuously until it flows out of the annulus at the surface. Any temporary casing if used or auger flights shall be removed immediately and in advance of the time when the grout begins to set. Casing removal and injection may proceed concurrently provided the top of the column of grout is always at least twenty feet above the bottom of the casing and provided injection is not interrupted. If casing removal does not commence until grout injection is completed, then additional grout shall be periodically poured into the annular space so as to maintain a continuous column of grout up to the ground surface. Grout which has overflowed the well hole shall be carefully removed so as to prevent the formation of horizontal projections (mushrooming) which may be subject to frost heave. The well shall not be disturbed for 48 hours to permit the grout to gain sufficient strength.

7.4.8. Placement of Protective Well Monument, Concrete Pad/Seal

A well protector as shown in Figures 8-1 and 8-2 shall typically be constructed before the grout has set. The well protector shall be positioned and maintained in a plumb position with temporary braces as required. An eight inch clearance between the top of the riser and the well protector shall typically be maintained for the sampler. A 1/4 inch diameter hole shall usually be drilled in the well protector 6 inches above the ground surface to permit water to drain out of the annular space. Coarse sand and/or pea gravel shall be placed in the annular space at least 6 inches above the hole to prevent insects from entering through the drilled hole. A 4-inch thick concrete pad shall be constructed around the protective monument. The pad should be approximately 2 to 3 feet in radius and should slope slightly away from the monument on all sides. Three protective "bumper" posts may be installed evenly spaced around the well at a 3 to 5 foot radius. Each post should be flagged and/or painted for improved visibility. If the monument is to be painted, the monument shall be painted before placing it in the grout.

A permanent, weatherproof, well identifier shall be affixed to the outside of the protective well monument (check state regulations for monitoring well labeling requirements).

7.5. Well Development and Acceptance

This section covers the development of a newly constructed well and the measurement of the well characteristics.

7.5.1. Pumps and Accessories for Well Development

All wells shall be developed to produce representative formation water. This section describes the approved pumps and accessories to be used in development of monitoring wells. All pumps and other devices used in well development shall be clean and free of oil, grease, solvents, or any other contaminants.

7.5.1.1. Submersible Pumps

Submersible pumps shall include electric motor powered or pneumatic units. If a submersible pump is utilized for well development, it shall be of a type and capacity such that it can pump water from the well continuously for a period of at least five minutes without shutting off. Backpressure or other methods may be utilized to accomplish the desired rate of pumping. The pump shall be capable of being turned on and off instantaneously to create surging in the well. In almost all cases the pump shall <u>not</u> be fitted with a backflow check valve.

7.5.1.2. Bladder Pumps

A bladder or diaphragm pump shall operate by compressed air cycling to inflate and deflate a diaphragm which creates a pumping action. They should be of sufficient capacity to influence the monitored zone.

7.5.1.3. Jet Pumps

Jet pumps use the Venturi principle to create subatmospheric pressure to allow the pump to be used below a depth at which suction alone would not normally lift the water. Jet pumps approved for well development shall be capable of pumping at least 3 gpm continuously when installed in the well or piezometer.

7.5.1.4. Bailers

Bailers shall not be used for well or piezometer development except after an approved submersible bladder, jet or suction pump has been installed in the well or compressed air or bottled nitrogen has been used, and/or the rate of well recovery is so slow that these methods are ineffective. Small diameter wells may also require bailing for development due to the limited access of the casing diameter.

7.5.1.5. Compressed Air

Compressed air supplied by an engine-driven compressor equipped with an approved oil filter and trap may be used provided the source of compressed air is capable of evacuating 50 percent of the column of water from the well once every minute.

7.5.1.6. Bottled Nitrogen

Bottled nitrogen may be used provided a regulator is employed and the system is capable of evacuating 50 percent of the column water from the well once every minute.

7.5.2. Well Development

Well development should begin after the monitoring well is completely installed and prior to water sampling. Development should be continued until representative water, free of the drilling fluids, cuttings, or other materials introduced during well construction is obtained. Representative water is assumed to have been obtained when pH, temperature, and specific conductivity readings stabilize and the water is visually clear of suspended solids (verify whether or not local regulations have development criteria for turbidity measurements). The minimum duration of well development should vary in accordance with the method used to develop the well. For example, surging and pumping the well may provide a stable, sediment free sample in a matter of minutes; whereas, bailing the well may require several hours of continuous effort to obtain a clear sample. The duration of well development and the pH, temperature, and specific conductivity readings should be recorded in the daily log and on the Monitoring Well Installation Log (Exhibit C) by the Field Supervisor.

Purged groundwater shall be captured and contained in 55 gallon steel drums or suitable vessel(s), if a reasonable potential exists for the groundwater to contain hazardous substances as directed by the Project Manager or as specified in the project work documents.

If required, each drum or vessel containing captured purge water shall be properly labeled with a weather proof label as to the contents, the well(s) from which the contained purge water originated and the date on which the contents were generated. Storage of the containers shall be as specified in the project work documents or as directed by the Project Manager.

Captured and contained purge water shall be characterized for discharge, treatment and/or disposal. Characterization of the captured and contained purge water should be specified in the project work documents or by the Project Manager, but could rely on site knowledge, the analytical results of groundwater samples associated with each container, or could involve direct sampling and analyses of the contained water.

The requirements and options available for discharge, treatment and/or disposal are dependent upon many variables such as chemical consistency, local and state regulations and location of site. Discharge, treatment and/or disposal of captured and contained purge water must be in accordance with local, state and Federal regulations and shall be specified in the project work documents.

Water levels should be measured from ground surface or the concrete pad at the base of the well monument.

7.5.3. Well Recovery Test

A recovery test shall typically be performed immediately after development. Readings shall be taken at appropriate intervals (usually one minute or less) until the well has recovered to within 90% of its static water level. The extremely long recovery periods of some wells may prohibit carrying this test out to its completion; the decision to terminate shall be noted and justified on the Well Installation Log.

7.5.4. Well Acceptance

The final completed well shall be probed using a weighted engineering tape to determine that the well is unobstructed to total depth. A 10-foot rigid cylinder 1 standard size smaller than nominal well casing size can be lowered to the total depth of the well and retrieved to verify straightness of the well for tool access.

A well will be accepted by the Field Supervisor when development has been completed in accordance with these specifications, and the required drilling subcontractor's documentation has been furnished to Golder.

7.6. Site Cleanup

The Staging area, decontamination area, each well site and any other areas used during the well installation program shall be cleaned up by the subcontractor and inspected by the Field Supervisor. Unless agreed with the client, all trash should be removed; the 55-gallon drums of cuttings shall be organized into a temporary storage area and any concrete or asphalt that has been covered with mud shall be washed off. Cut or torn asphalt areas will be patched by the subcontractor using a cold patch material. Try to restore the area as much as possible to the condition before the well installation program.

7.7. Field Change Request

Variation from established procedure requirements may be necessary due to unique circumstances encountered on individual projects. All variations from established procedures shall be documented on a Field Change Request (Exhibit D) and reviewed by the Project Manager and the Project Director.

The Project Manager may authorize individual Field Supervisors to initiate necessary variations. If possible, the request for variation shall be reviewed by the Project Manager prior to implementation. If prior review is not possible, the variation may be implemented immediately at the direction of the Field Supervisor, provided that the Project Manager is notified of the variation within 24 hours of the implementation, and the Field Change Request is forwarded to the Project Manager within 2 working days of implementation. If the variation is unacceptable to either reviewer, the activity shall be reperformed or action shall be taken as indicated in the Comments section of the reviewed Field Change Request. All completed Field Change Requests shall be maintained in project records.

7.8. Well Location

The level of accuracy required for horizontal well location and elevation shall be specified by the Project Manager or applicable project plans. At a minimum, well locations shall be approximated with tape and compass from known permanent landmarks. However, locations may be measured by alternate methods such as (1) triangulated with compass bearings; (2) by GPS if of sufficient accuracy; and (3) geodetic survey using standard survey techniques. Elevation of the riser casing shall be approximated. A licensed surveyor, if required, shall maintain 3rd order precision and accuracy. The surveyed point for the well riser shall be the highest point on the riser casing with the slip cap removed. That point shall be marked on the riser casing.

8.0 REFERENCED GUIDELINES

Golder Associates Inc. Technical Guideline TG-1.2-1, "Rock Core Drilling and Sampling."

Golder Associates Inc. Technical Guideline TG-1.2-5, "Drilling, Sampling, and Logging of Soils."

Golder Associates Inc. Technical Guideline TG-1.4-6, "Water Level Measurement."

9.0 ADDITIONAL REFERENCES, GUIDELINES AND PROCEDURES

ASTM D 1785 - Threaded, Flush Couplings on PVC Pipe.

Golder Associates Inc. Technical Guideline TG-1.2-20 “Collection of Groundwater Quality Samples”
Golder Associates Inc. Quality Procedure QP-1, "Calibration and Maintenance of Measuring and Test Equipment."

Golder Associates Inc. Technical Guideline TG-1.2-23, "Chain of Custody."

Golder Associates Technical Guideline TG-2.3-3, “Headspace Analysis Using the Organic Vapor Analyzer”

Golder Associates Technical Guideline TG-1.1-2, "Geodetic Surveys."

Federal and/or State Regulations and Guidance

CFR 264/265 Subpart F

Resource Conservation and Recovery Act (RCRA) Ground-Water Monitoring

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

Applicable State Standard Operating Procedure

EXHIBIT A

Golder Associates

HISTORY OF HOLE

Job No. ____________ Sheet ______ of ______

Geologist ____________ Date ____________ Boring No. ____________
Driller ____________ Surface Elevation ____________ Weather ____________ Temp ____________
Contractor ____________ Drill Fluid ____________ ____________ To ____________
Location ____________ Type of Barrel ____________ Casing Size ____________ Core Size ____________

BEGINNING OF SHIFT	END OF SHIFT
Time ______ Depth of Hole ______	Time ______ Hrs Productive ______ Hrs. Delayed ______
Depth to WL ______ Depth of Casing ______	Depth of Hole ______ Depth of Casing ______ Depth to WL ______

Checked by:

EXHIBIT B

Golder Associates
Field Boring Log

DEPTH HOLE ______	JOB NO. ______	PROJECT ______	BORING NO. ______
DEPTH SOIL DRILL ______	GA INSP. ______	DRILLING METHOD ______	SHEET ______ OF ______
DEPTH ROCK CORE ______	WEATHER ______	DRILLING COMPANY ______	SURFACE ELEV. ______
NO. DIST. SA. ___ UD. SA. ___	TEMP. ______	DRILL RIG ______ DRILLER ______	DATUM ______
DEPTH WL. ______	HRS. PROD. ______	WT. SAMPLER HAMMER ______ DROP ______	STARTED ______ / ______ (TIME / DATE)
TIME WL. ______	HRS. DELAYED ______	WT. CASING HAMMER ______ DROP ______	COMPLETED ______ / ______

SAMPLE TYPES

A.S.	AUGER SAMPLE
C.S.	CHUNK SAMPLE
D.O.	DRIVE OPEN
D.S.	DENISON SAMPLE
P.S.	PITCHER SAMPLE
R.C.	ROCK CORE
S.T.	SLOTTED TUBE
T.O.	THIN-WALLED, OPEN
T.P.	THIN-WALLED, PISTON
W.S.	WASH SAMPLE

ABBREVIATIONS

BL	BLACK	M	MEDIUM	SA	SAMPLE
BR	BROWN	MIC	MICACEOUS	SAT	SATURATED
C	COARSE	MOT	MOTTLED	SD	SAND
CA	CASING	NP	NON-PLASTIC	SI	SILT
CL	CLAY	OG	ORANGE	SIY	SILTY
CLY	CLAYEY	ORG	ORGANIC	SM	SOME
F	FINE	PH	PRESSURE-HYDRAULIC	TR	TRACE
FRAG	FRAGMENTS	PM	PRESSURE-MANUAL	WL	WATER LEVEL
GL	GRAVEL	R	RED	WH	WEIGHT OF HAMMER
LYD	LAYERED	RES	RESIDUAL	Y	YELLOW
LI	LITTLE	RX	ROCK		

SOIL DESCRIPTION - RANGE OF PROPORTION

"TRACE" 0 - 5% "SOME" 12 - 30%
"LITTLE" 5 - 12% "AND" 30 - 50%

RELATIVE DENSITY		BLOWS	CONSISTENCY		FINGER PRESSURE
VERY LOOSE	VLS	0-4	VERY SOFT	VS	EXTRUDES
LOOSE	LS	4-10	SOFT	S	MOLDS EASILY
COMPACT	CP	10-30	FIRM	FM	MOLDS
DENSE	DN	30-50	STIFF	ST	THUMB INDENTS
VERY DENSE	VDN	50	VERY STIFF	VST	THUMBNAIL INDENT
			HARD	H	RESISTS THUMBNAIL

ELEV. / DEPTH	DESCRIPTION	BLOWS / FT		SAMPLES NO.	TYPE	HAMM. BLOWS PER 6 IN (FORCE)	REC / ATT	DEPTH	SAMPLE DESCRIPTION AND BORING NOTES

EXHIBIT C

MONITORING WELL INSTALLATION LOG

JOB NO. ______ PROJECT ______ WELL NO. ______ SHEET ______ OF ______

GA INSP. ______ DRILLING METHOD ______ GROUND ELEV. ______ WATER DEPTH ______

WEATHER ______ DRILLING COMPANY ______ COLLAR ELEV. ______ DATE/TIME ______

TEMP. ______ DRILL RIG ______ DRILLER ______ STARTED ______ (TIME / DATE) COMPLETED ______ (TIME / DATE)

MATERIALS INVENTORY

WELL CASING ______ in. dia. ______ l.f.

CASING TYPE ______

JOINT TYPE ______

GROUT QUANTITY ______

GROUT TYPE ______

WELL SCREEN ______ in. dia. ______ l.f.

SCREEN TYPE ______

SLOT SIZE ______

CENTRALIZERS ______

DRILLING MUD TYPE ______

BENTONITE SEAL ______

INSTALLATION METHOD ______

FILTER PACK QTY ______

FILTER PACK TYPE ______

INSTALLATION METHOD ______

ELEV./DEPTH	SOIL/ROCK DESCRIPTION	WELL SKETCH	INSTALLATION NOTES
	GROUND SURFACE		
0.0			

WELL DEVELOPMENT NOTES

EXHIBIT D

FIELD CHANGE REQUEST

Job/Task Number: __________

Other Affected Documents: __________

Requested Change: __________

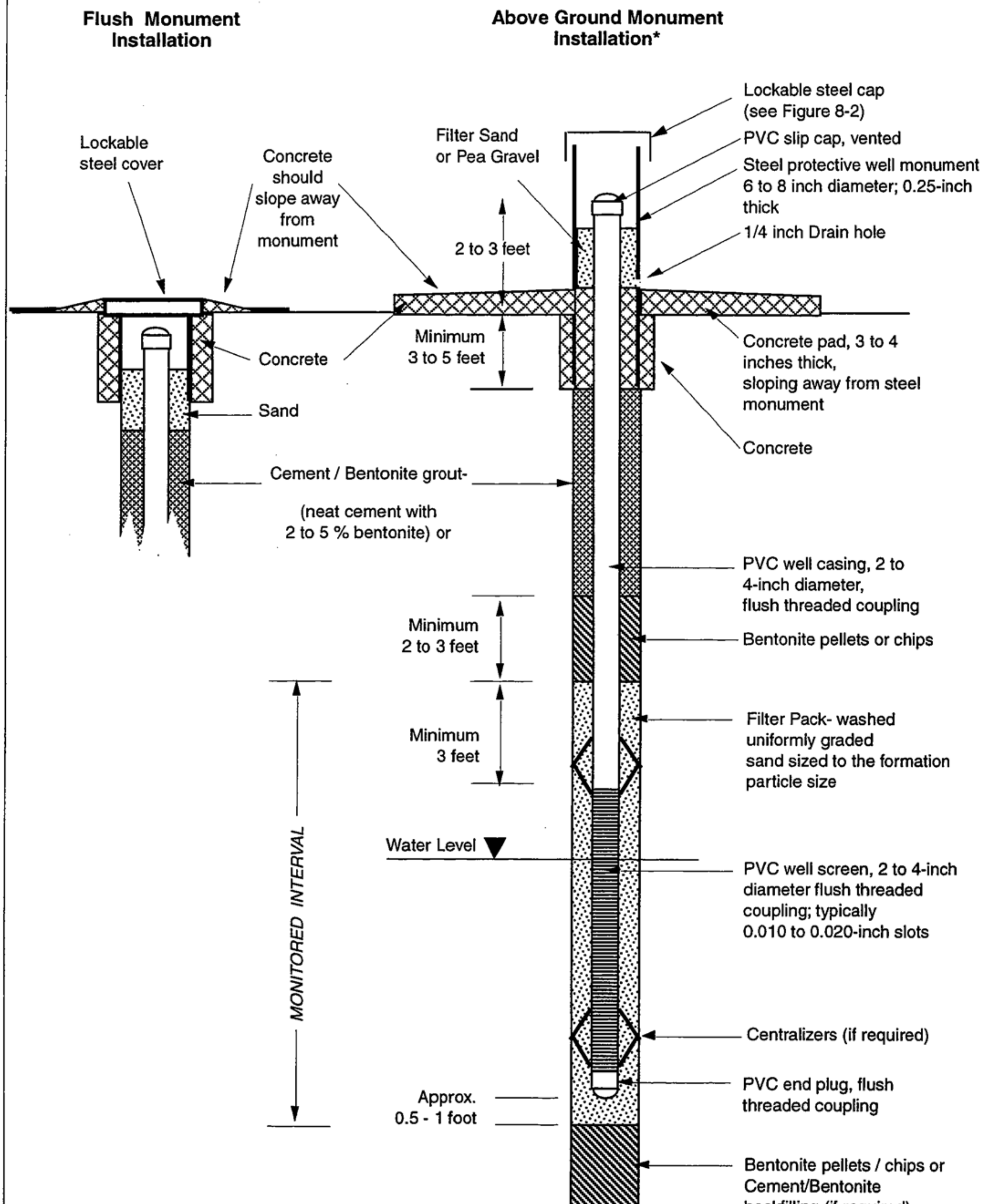
Reason for Change: __________

Change Requested by: __________ Date __________

Reviewed by: __________ Date __________
GAI Project Manager

Comments: __________

FIGURE 8-1

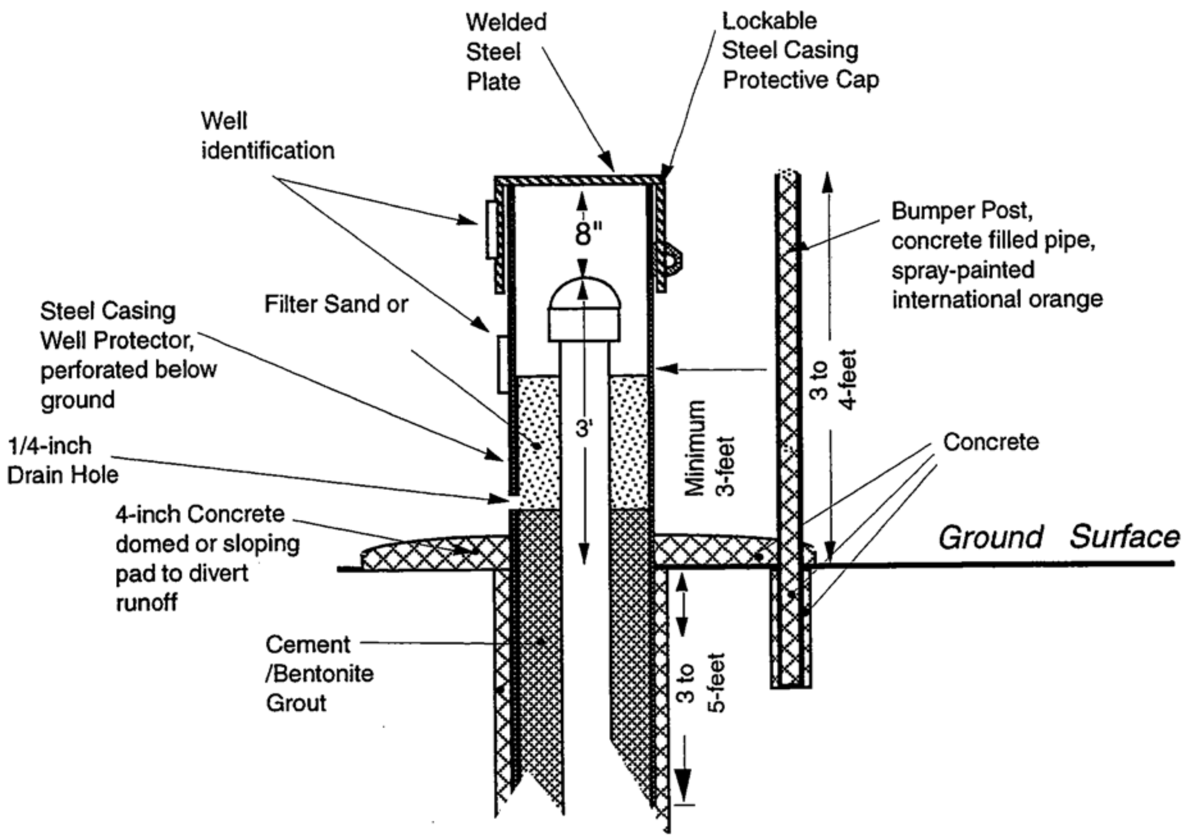


* See Figure 8-2 for protective cap and monument details

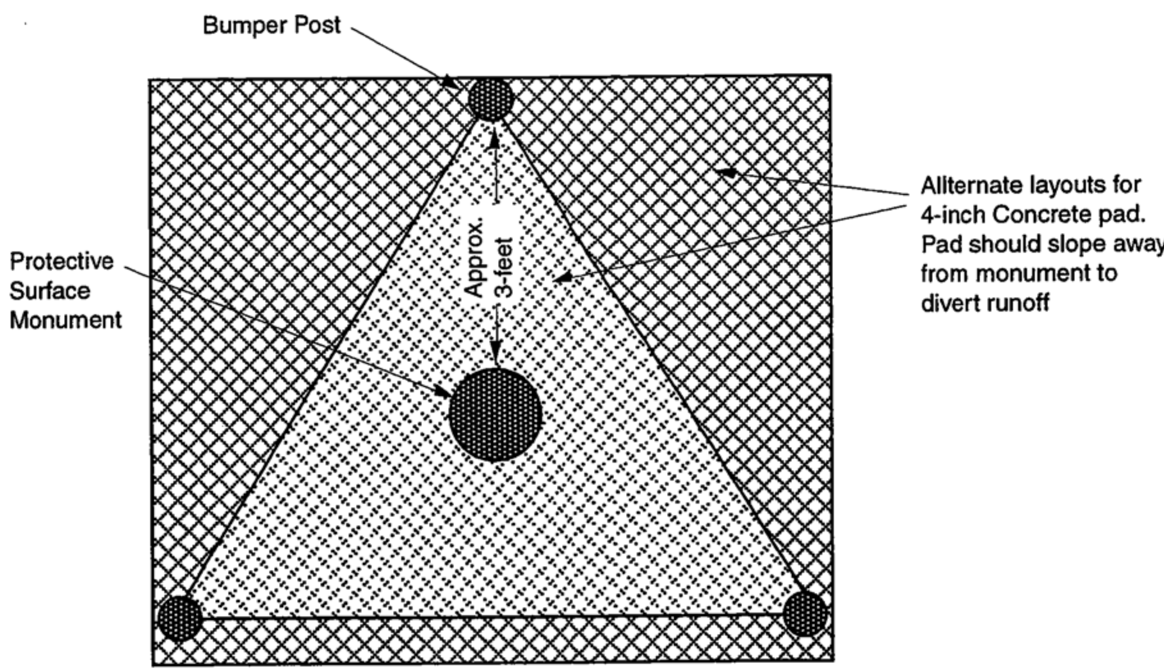
Not To Scale

FIGURE **8-1**
TYPICAL MONITORING WELL INSTALLATION

FIGURE 8-2



Cross Section
Protective Above-Ground Monument



Plan View
Protective Monument and Pad

FIGURE **8-2**
PROTECTIVE MONUMENT DETAILS

TECHNICAL GUIDELINE FOR
COLLECTION OF GROUNDWATER QUALITY SAMPLES
TG-1.2-20

Rev. #3
8/20/2009

Table of Contents

List of Tables

List of Exhibits

TG-1.2-20 Collection of groundwater quality samples

1.0 PURPOSE

This technical training guideline establishes a standard methodology for collecting groundwater samples for chemical analysis that are representative of aquifer water quality.

2.0 APPLICABILITY

This technical training guideline is applicable to field personnel engaged in the collection of groundwater samples from wells for purposes of chemical analysis. This document should be read in conjunction with any and all regulatory, workplan, order, client specific, and other project-specific guidelines.

3.0 DEFINITIONS

3.1. Dedicated Pump System

A dedicated pump system is a permanently installed device for removing water from a well. The system is not removed from the well and does not have the potential to become cross-contaminated between uses.

3.2. Well Bore Storage Volume

Well bore storage volume is defined as the volume of water enclosed by the well casing and screen gravel/sand pack at equilibrium.

3.3. Bailer

A bailer is a tubular device with a check-valve at the top and/or bottom for collecting and removing groundwater from wells.

3.4. Non-Dedicated Sampling Apparatus

Non-dedicated sampling apparatus is sampling equipment that may contact groundwater samples from more than one well. This term is also used to describe equipment that is only used for sampling a single well, but is removed from the well and could potentially become contaminated.

3.5. Groundwater Sample

A groundwater sample is defined as water acquired from a well for analyses of chemical or biological parameters that is representative of groundwater within the aquifer or the portion of the groundwater in the subsurface being sampled.

3.6. Positive Pressure Pump

A positive pressure pump is a device for removing water from a well by forcing water to the surface through positive pressure when operated below the well's water level. A positive pressure pump may be operated electrically, mechanically, or by gas pressure. Submersible impeller, bladder, and check valve pumps are common types of positive pressure pumps.

3.7. Negative Pressure Pump

A negative pressure pump is a device for removing groundwater from a well by suction (negative pressure). Peristaltic and centripetal pumps are common types of negative pressure pumps. The limitation for lifting water by suction is usually 20 to 25 feet. These pumps are typically only acceptable for non-volatile analytes and analytes that are not affected by aeration or changes in pH or pressure. They are useful as purging devices for shallow groundwater wells.

3.8. Sample Bottles

Sample bottles are containers specifically designed and prepared for storing aliquots of a sample. Sample container type, material, size, and type of lid are specific for particular groups of analytes. Sample bottles must typically be properly cleaned and prepared by a certified laboratory.

3.9. Acceptable Material

Acceptable materials are defined as the only materials that are allowed to contact groundwater samples, and are dependent on the analytes being tested.

3.10. Permissible Pump

Permissible pumps are defined as pump systems that have acceptable effects on water quality when used to obtain groundwater samples from wells. The use of permissible pumps is dependent on the analyses being conducted on the acquired samples. The parts of permissible pumps that will contact the groundwater sample contain only acceptable materials.

4.0 DISCUSSION

In order to generate appropriate, quality data using these guidelines, it is incumbent on the field personnel to have reviewed these guidelines as well as other referenced and/or pertinent technical guidelines. This document should be read in conjunction with any and all regulatory requirements, site-specific work plans, administrative orders, and client- specific or other project-specific guidelines.

Groundwater samples shall be collected in quantities and types as directed by the Project Manager and project work documents. If applicable, sampling or monitoring shall be conducted for any potential floating immiscible layers prior to well purging and sampling. All instruments used for field analyses shall be calibrated in accordance with appropriate guidelines. The guidelines in Golder Associates Quality Procedure QP-1, "Calibration and Maintenance of Measuring and Test Equipment" may be applicable, however it is important to be familiar with local regulatory and project-specific requirements.

All non-dedicated sampling equipment shall be decontaminated before and after each use. If directed by the Project Manager or as specified in project work documents, purge water and decontamination fluids shall be captured and contained for disposal. Samples shall be collected in properly prepared containers of the appropriate size and type (see Table 1). All samples shall be appropriately labeled and sealed (see Exhibit A) an appropriate groundwater sample collection forms (Exhibit B) must be used to document raw field information for each sample. Chain of custody (see Exhibit C) shall be maintained in accordance with guideline TG-1.2-23, "Chain of Custody." The Field Report Form (see Exhibit D) and Sample Integrity Data Sheet (see Exhibit E) and bound field notebooks shall be used to document daily site activities and sample collection. All variations from established guideline shall be documented on the Field Change Request (see Exhibit F) and shall be approved by the Project Manager.

5.0 RESPONSIBILITIES

5.1. Sampling Technician

The Sampling Technician is responsible for sample collection, sample custody in the field, preservation, field testing, total and accurate completion of data sheets, sample shipment and delivery of data to the Project Manager, all as described in this technical guideline.

5.2. Task Leader

The Task Leader is responsible for supervising Sampling Technicians. Supervision includes ensuring that samples are collected, documented, preserved, field analyzed, handled and shipped to the appropriate laboratory as specified in project work documents and this technical guideline. In many cases, the Task Leader will also fill the role of the Sampling Technician.

5.3. Project Manager

The Project Manager has overall management responsibilities for the project, is responsible for designing the sampling program, for arranging the logistics of the program, and for providing any required clarifications in the use of this guideline.

6.0 EQUIPMENT AND MATERIALS

If wells are equipped with permissible and dedicated pump systems, equipment to operate the dedicated pump systems (i.e., air compressor, compressed air or nitrogen cylinders, electric generator, etc.); non-dedicated sampling apparatus such as surface discharge tubing and valving; or bailer(s) for sampling free floating product may be necessary.

If wells do not have permissible and dedicated pump systems, permissible pump systems or bailers and accessories of small enough diameter to enter the wells will be necessary. All equipment that could contact the sample shall be made of acceptable materials.

Additional supplies should include: sample bottles, properly cleaned and prepared by a certified laboratory with preservatives appropriate for the parameters to be sampled.

Field test equipment

- multi parameter meter and calibration standards (meter should be capable of measuring pH, specific conductance, redox, dissolved oxygen and temperature);
- turbidity meter and calibration standards;
- flow through cell for collection of field measurements;
- Filtration apparatus (0.45 micron and prefilter), if necessary;
- Depth to water measuring device;
- Interface probe if necessary;
- Well specifications;
- Sample labels and seals (Exhibit A);
- Groundwater Sample Collection Forms (Exhibit B);
- Chain of Custody Forms (Exhibit C);
- Field Report Forms (Exhibit D);
- Sample Integrity Data Sheet (Exhibit E);
- Coolers and ice packs or wet ice contained in zippered plastic bags;
- HPLC/distilled/deionized/Type II water as necessary;

- Isopropyl alcohol;
- 1% solution of trace metal grade nitric acid;
- Cleaning equipment and solutions;
- Indelible ink pens;
- Field notebooks;
- Container(s) for capturing, containing, treating and measuring waste decontamination solutions, if necessary;
- OVA or OVM with accessories and calibration gases;
- As required, 55 gallon steel drums fitted with bung holes, or suitable vessels(s) for containing purged groundwater;
- Field Change Request (Exhibit F);and
- Appropriate PPE, notably suitable gloves for handling samples. Various gloves may react to potential contaminants, so glove selection should be made carefully prior to mobilizing to the field.

7.0 GUIDELINE

7.1. General Considerations

7.1.1. Regulatory Considerations

At most locations, groundwater sampling and the characterization and disposal of purge fluids are specifically regulated by local, or state regulations, or may have client specific requirements. All such client and regulatory requirements must be reviewed before groundwater sampling. At a minimum, the following actions must be taken:

Ensure that groundwater sampling is performed by an entity that meets all requirements for conducting such operations in that particular location; and

Ensure that all follow up well reports required by appropriate agencies are submitted to the appropriate authorities or in some cases that we have informed the client of such requirements.

7.1.2. Decontamination

All non-dedicated sampling equipment that may contact the sample must be decontaminated before and after each use. Non-dedicated pumps or bailers require decontamination of internal and external parts prior to being lowered into the well. Non-dedicated equipment shall typically first be washed with clean tap water (whose chemistry is known and acceptable), non-phosphate detergent (e.g., Alconox), and rinsed with clean tap water. For inorganic analytes 1% nitric acid solution shall be used for a second rinse. For organic analytes, reagent-grade isopropyl alcohol is often used for the second rinse. A final rinse with HPLC/distilled/deionized/Type II water shall complete the decontamination. At a minimum, all acid and isopropyl alcohol wash solutions must be captured (see Section 7.4.2).

7.1.3. Sample Quantities, Types, and Documentation

Samples shall be collected in quantities and types as directed by the Project Manager or as specified in the project work documents. The Field Report Form (Exhibit D) or field notebook and the Sample Integrity Data Sheet (Exhibit E) shall be used to document daily site activities and sample collection (see Section 7.5). Samples shall be transferred to the analytical laboratory under formal chain of custody, which shall be documented (Exhibit C) and maintained in accordance with guideline TG-1.2-23, "Chain of Custody".

7.1.4. Sample Containers

Table 1 provides a summary of the typical type and minimum size of the sample bottles, preservation, storage/handling requirements, and maximum holding times for some common chemical analyses performed on groundwater samples for environmental investigations. All sample bottles must be properly cleaned and prepared by a certified laboratory. All groundwater samples shall be labeled and typically sealed (see Section 7.5) and immediately placed in coolers that have been pre-cooled to 4°C or less and that have securely closed lids for storage and transport. Samples must be received by the analytical laboratory in sufficient time to conduct the requested analyses within the specified holding time. All samples should be placed on ice and stored at 4°C immediately following sampling unless otherwise indicated in the site-specific work plan.

7.1.5. Acceptable Materials

The choice of materials used in the construction of sampling devices should be based upon knowledge of what analytes may be present in the sampling environment and how the sample material may interact.

Typically acceptable materials that may contact groundwater sample are stainless steel and fluorocarbon resin (Teflon, PTFE, FEP, or PFA). Glass is an acceptable material for contacting some samples. Plastics (PVC, polyethylene, polypropylene, tygon) are an acceptable material for contacting some samples, often when the analyses are for inorganic analytes (metals, radionuclides, anions, cations).

7.1.6. Sample Acquisition

Groundwater samples shall typically be removed from the well with the use of a permissible pump or bailer. Electric positive-pressure pumps made of acceptable materials as defined in Section 3.0 are permissible to use for acquiring any groundwater sample. Gaseous, typically air or nitrogen pressure activated positive-pressure pumps made of acceptable materials are permissible to use for acquiring any groundwater sample if the gas does not contact the sample. Positive-pressure pumps operated by mechanically forcing water through check valves are often permissible for acquiring any groundwater samples. Bailers made of acceptable materials are permissible for acquiring groundwater samples in some circumstances.

Peristaltic pumps and air-lift pumps are not preferred for acquiring groundwater samples but are often permissible when samples are to be analyzed for analytes that are not affected by aeration, and are not affected by changes in pH or pressure.

Other types of pumps (peristaltic, centrifugal, air lift, recirculation, etc.) may typically be used for purging groundwater from wells prior to sample acquisition, if: (1) pump materials contacting well water are acceptable; (2) pumping does not aerate or change the pH of the remaining well water; and (3) pumped water does not mix with remaining well water during pumping or after the pumping is stopped.

The appropriate pump should be selected by the Project Manager prior to mobilizing to the field.

7.2. Groundwater Sample Acquisition

7.2.1. Floating or Sinking Non-Aqueous Fluids

Groundwater shall be examined for the presence of any floating or sinking non-aqueous fluids, in unknown situations or where they may be potentially present, at the direction of the Project Manager. If detected, they shall be sampled prior to purging any water from the well. An interface probe is often used for this purpose along with measurement of the liquid/water level. Guideline TG-1.4-6, "Water Level Measurement" may be applicable. A bailer (preferably with a check valve at the bottom only and made of transparent Teflon or glass) may be lowered into the well to retrieve a sample of floating non-aqueous fluid. The bailer shall not become completely submerged. A sample of sinking non-aqueous fluid can often be obtained using a stainless steel device designed specifically for discrete interval sampling. If a non-aqueous fluid is sampled, it may be transferred to a 40 ml or 125 ml glass vial with an air-tight, Teflon-lined septum cap. The sample shall not be filtered or preserved with additives, but shall typically be placed in a metal can with vermiculite and then in a cooler that has been pre-cooled to 4°C and secured for storage and transport. There are often very stringent requirements for transport of such samples.

7.2.2. Purging the Well

It is often preferable to conduct well purging using a low flow/low stress methodology. Purging shall be conducted by starting the pump at its lowest setting and slowly increasing the pumping rate until flow occurs (typically flow rates on the order of 0.1 to 0.4 l/min). Ideally at this pumping rate, there should be a minimum level of water level drawdown (generally less than 10 cm). Monitor and record the pumping rate and water level as appropriate during purging. During purging, monitor indicator field parameters (e.g., turbidity, temperature, specific conductance, pH, ORP, DO) every three to five minutes. Purging is considered complete and sampling may begin when the indicator parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken on 3 to 5–minute intervals, are within the following tolerance:

- Turbidity (within 10% and preferably less than 5 NTU);
- Temperature (within 0.5 degrees C);
- Specific conductance (within 10%);
- pH (within 0.1 stnd pH units);
- ORP (within 10%); and
- DO (within 10%).

If the low flow/low stress methodology is not used, the pump or bailer shall be used and operated in accordance with the manufacturer's operational manual. Before collecting the actual groundwater sample field parameters of at least pH, redox, temperature, and specific conductivity should come to stabilize or approach asymptotical values. In general this will require that a minimum of three (3) well bore storage volumes of water shall be purged from the well by pumping. Calculate this volume by measuring the depth to water and subtracting this depth from the total depth of the well. If a gravel/sand pack surrounds the screen the pore volume of the gravel/sand pack (assume a porosity of 25 percent if unknown) shall be added to the total well volume. While purging water from the well, parameters specified by the Project Manager will be monitored.

A flow-through cell is advantageous for the monitoring of field indicators. Typically, if the parameters are within the ranges specified above, then the water has stabilized. Rarely are more than ten well volumes removed before sampling using these criteria. If the parameters of interest in the investigation include VOCs, care must be taken to ensure that purging does not induce degassing within the well. Where the well screen and sand pack are completely below the water table, the rate of purging should be controlled such that it does not draw the water level in the well below the top of the well screen. Where the well screen and sandpack are intersected by the groundwater level, the rate of purging should correspond with the rate of sampling, if continuous sampling methods are used. Large drawdowns in water table wells should be avoided. Purged groundwater that has a reasonable potential of containing hazardous substances shall be captured and characterized prior to discharge or disposal (see Section 7.4.1). Where a low yielding well is encountered, the Project Manager shall be contacted for direction (see Section 7.6).

7.2.3. Samples for Major Cation, Metal and Metallic Radionuclide Analyses

Samples for major cations and metallic radionuclide analyses are sometimes filtered immediately or within two hours after acquisition. However, most projects require that samples for cations are not filtered. Filtration is best accomplished with the use of an in-line filter system in which the sample is directly fed from the discharge port of permissible positive-pressure pump through the filter and into the appropriate sample bottle. A less preferred but acceptable method is the collection of an adequate amount of sample from a permissible positive-pressure pump or bailer into a properly cleaned and prepared high-density linear polyethylene or glass prefiltration bottle. The prefiltration bottle does not contain any chemical preservative. Aliquots shall be immediately fed through the filter and collected directly into the appropriate sample bottle. The final filter pore size should typically be 0.45 microns. (Note: New filters made of material specified by the Project Manager shall be used for each sample and the filter system must be decontaminated before and after each sample.) These groundwater samples shall be preserved with nitric acid (HNO3) to a pH less than 2. A new capillary tube can be used to remove fluid from the bottle and dabbed onto pH indicator paper to check that the pH is less than 2.

An unfiltered aliquot of a sample can typically be obtained (in addition to the filtered aliquot) directly from a permissible positive-pressure pump discharge port or from the bailer into appropriate sample bottles (see Table 1) and preserved with nitric acid to a pH less than 2. Note that for various cations, including chromium VI, no acid and typically no other chemical preservative is added to the aliquot.

7.2.4. Samples for Semi-Volatile Organics Including Extractable Base-Neutral/Acid Compounds, Phenolic Compounds, Pesticides, PCBs and Herbicides

Samples for semi-volatile organics including extractable base-neutral/acid compounds, phenolic compounds, PCBs, pesticides, or herbicides analyses shall typically be collected directly from a positive-pressure pump discharge port or bailer in appropriate sample bottles often with a Teflon lined lid and in some cases an appropriate chemical preservative. Sample should not be allowed to overflow the sample bottle and in the vast majority of cases shall not be filtered unless specified in a project-specific work plan.

7.2.5. Samples for Purgeable Volatile Organics

Samples for purgeable volatile organics are obtained before samples for other analytes have been acquired for each well. In wells with low productivity, volatile organics should be the first samples taken, unless otherwise directed by the Project Manager. Samples for purgeable volatile organics shall typically be obtained from the well using a permissible positive-pressure pump or bailer and shall be collected directly from the pump discharge tube or bailer into properly cleaned and prepared 40 ml vial.

The sample should not be allowed to overflow the sample bottle as this may remove acid preservative that is usually added at the laboratory either prior to sample shipment to the field or by field staff before filling the vials. The pH of the aliquot should be checked if acid preservative is used and the buffering capacity of the groundwater is high or unknown or more turbid than usual from a carbonate rich strata. A new capillary tube can be used to remove fluid from the bottle and dabbed onto pH indicator paper to check that the pH is less that specified by the methodology for acid preserved samples – often less than pH 2.

Air contact and sample agitation should be minimized. Pumping rates should be significantly reduced during sampling for volatile organics to reduce potential agitation of the sample. These samples shall not be filtered or preserved except as noted below. The bottle should be filled until there is a convex meniscus to facilitate an airtight seal when capped. Immediately after collection, a Teflon lined silicon septum cap shall be placed Teflon side down tightened onto the vial. There should be no air bubbles remaining within the vial once the cap has been fastened; if air is present, a new sample shall be taken by the same guideline.

Samples for many volatile methods are preserved with hydrochloric acid (HCl) to increase holding time. However, in some waters the acid will react with the sample producing bubbles due to production of carbon dioxide or sulfur compounds. If bubbles are found due to reactions with the acid, contact the Project Manager if this eventuality has not been described in the work plan. The Project Manager may require that samples are taken without acid preservative with the resulting shorter holding times. In this case a new unpreserved vial should be used. An unpreserved sample vial can be obtained by pouring the acid out of a preserved vial if no unpreserved vials are available. It is unlikely that the remaining acid will be sufficient to produce bubbles. However, if bubbles are still found one may slowly fill and empty the vial once or more times to remove the remaining acid. Samples that are not preserved should be noted as such on both the bottle labels and the Chain of Custody documents.

7.2.6. Samples for Cyanide Analyses

Samples for cyanide analyses shall be collected directly into appropriate sample bottles from the bailer or the port of a permissible positive-pressure pump. Samples shall not be filtered nor shall they be allowed to overflow the sample bottle. A pre-preserved bottle is typically made available. Otherwise, samples shall be immediately preserved with sodium hydroxide (NaOH) to a pH greater than 12. A new capillary tube can be used to remove fluid from the bottle and dabbed onto pH indicator paper to check that the pH is greater than pH 12.

7.2.7. Samples for Major Anion and Biological Oxygen Demand (BOD) Analyses

Samples for major anions (chloride, fluoride, sulfate, alkalinity, acidity, total silica, bromide) and for biological oxygen demand shall be collected directly into appropriate sample bottles from the port of the pump or from the bailer. These samples do not require filtration, but may be filtered if explicitly required in the sampling plan. Chemical preservatives shall only be added as required by the method.

7.2.8. Samples for Total Phosphate and Orthophosphate Analyses

Groundwater samples for total phosphate and orthophosphate analyses shall typically be immediately filtered after initial sample acquisition. However, these parameters often are specified to be taken without filtration. Filtration is best accomplished with an in-line system in which a positive-pressure pump discharge port feeds groundwater directly through the filter system into an appropriate sample bottle. A less preferred but acceptable method to obtain a filtered sample is to collect a liter of sample from a permissible positive-pressure pump or bailer in a properly cleaned and prepared high-density polyethylene or glass bottle, and then immediately feed the sample through a filter system (e.g., syringe filters) which discharges into the appropriate sample bottle. This process should be completed within two hours; otherwise, the results will be suspect. The final filter pore size shall typically be 0.45 micron. (Note: New filters made of most any material must be used for each sample and the filter system must be decontaminated before and after each use.) Samples shall be immediately placed on ice and preserved by cooling to 4°C or lower.

7.2.9. Samples for Total Phosphorus, Nitrogen Compounds, Chemical Oxygen Demand, Total Organic Carbon, and Total Organic Halogen Analyses

Groundwater samples for total phosphorus, nitrogen compounds, chemical oxygen demand, and total organic carbon analyses shall be collected directly into appropriate sample bottles from a permissible positive pressure pump discharge port or from the bailer. These samples shall not be filtered and shall be chemically preserved as required by the various methods.

7.2.10. Samples for Analysis of Total Dissolved Solids

Groundwater samples for analyses of total dissolved solids shall be immediately filtered in the field by methods discussed in Section 7.2.3 above or collected without filtration depending on sampling plan, and put directly into an appropriate sample bottle. Samples shall not be preserved with chemicals.

7.2.11. Samples for Oil and Grease or Hydrocarbons

Groundwater samples for oil and grease or hydrocarbons shall be collected directly into the appropriate sample container from the discharge port of a permissible positive pressure pump or from the bailer. These samples shall not be filtered and in some cases shall be preserved with hydrochloride acid (HCL, 1 + 1 Vol/Vol) to a pH less than 2. A new capillary tube can be used to remove fluid from the bottle and dabbed onto pH indicator paper to check that the pH is less than 2. Do not preserve with sulfuric acid due to potential interferences in the analytical procedure from co-extraction of elemental sulfur.

7.2.12. Samples for Fuel Fingerprinting

Groundwater sample for fuel fingerprinting shall be collected directly into the appropriate sample container using a permissible positive pressure pump or bailer and shall be collected directly from the pump discharge tube or bailer. Some guidelines require that the sample be allowed to overflow approximately 2 to 3 sample container volumes minimizing agitation and contact with air. These samples shall not be filtered but typically must be preserved to a pH <2 with HCL (1:1 vol/vol). A new capillary tube can be used to remove fluid from the bottle and dabbed onto pH indicator paper to check that the pH is less than 2. The sample container is then often capped with a Teflon lined silicon septum cap excluding all headspace. Otherwise the sample is often split into two or three aliquots for different analyses as dictated in the sampling plan or as specified by the Project Manager.

7.3. Field Analyses

7.3.1. Calibration of Instruments

All instruments used for field analyses shall be calibrated in accordance with guidelines required by the sampling and analysis plan; or by the most strict single guideline or combination of guidelines compiled from procedure QP-1, "Calibration and Maintenance of Measuring and Test Equipment;" or by the method or manufacturer's procedure. Only equipment with a calibration tag showing a validity date later than the anticipated date of use shall be taken to the field unless, as is usual, field calibration is performed. Each instrument should be accompanied by a copy of the manufacturer's operation manual and appropriate instrument calibration records.

7.3.2. Water Temperature

A meter and a flow though cell are the preferred tools for measuring this parameter. The meter shall be calibrated in accordance with the sampling plan, and if more stringent, with the manufacturer's procedures (provided with the instrument). If a meter is unavailable, a thermometer shall be used to measure the temperature of the water on an aliquot of purged water obtained just before sampling. The thermometer reading shall be allowed to stabilize and shall be recorded to the nearest 0.5°C. The thermometer shall be rinsed with distilled/deionized water before and after each use.

7.3.3. pH Measurement

A meter and a flow though cell are the preferred tools for measuring this parameter. Alternately, a pH meter may be used to measure the pH of the sample on an aliquot of purged water that was obtained just before sampling. Measurements shall be made immediately on the obtained aliquot. (Note: If possible, measure pH continuously on the purged water in an air-space free and closed flow-through system.) Calibration shall be in accordance with the sampling plan or, if more stringent, with the manufacturer's procedures (provided with the instrument). At a minimum, calibration shall be performed at the beginning and ending of each day's use and every four hours in between. Calibration shall be performed with standardized buffered pH solutions and conducted as required by the more stringent of the sampling plan or manufacturer's specifications. Typically, the probe shall be thoroughly rinsed with distilled/deionized water after each sample when using a flow through cell or after each sample reading when the probe is placed in a discrete aliquot of sample. The pH shall be recorded to one-hundredth, if the meter is stable enough of a pH unit.

7.3.4. Conductivity Measurement

A meter and a flow though cell are the preferred tools for measuring this parameter. Alternately, a conductivity probe may be used for conductivity measurement on an aliquot of purged water obtained just before sampling. Measurements shall be made as soon as possible on the obtained aliquot. The meter shall be calibrated in accordance with sampling plan or, if more stringent with the manufacturer's procedures (provided with the instrument) with standardized calibration solutions. It is preferable to have a range of calibration solutions that bracket the site conductivity range. At a minimum calibration shall be performed at the beginning and ending of each day's use and every four hours in between. The conductivity shall typically be recorded to two significant figures and rarely more than three significant figures. The temperature of the sample at the time of conductivity measurement shall also be recorded. The probe must be thoroughly rinsed with distilled/deionized water before and after each use. It is imperative that the Sampling Technician record the correct units in which the conductivity measurements were taken.

7.3.5. Dissolved Oxygen Measurement

A meter and a flow though cell are the preferred tools for measuring this parameter. Alternately, a dissolved oxygen meter is used to measure dissolved oxygen (DO) in water samples. This test should be at best considered a rough estimation with most meters as the measurements are subject to a number of environmental interferences that may affect the results. Measurements shall be made immediately on aliquots obtained just before sample acquisition. (Note: If possible, measure DO continuously on the purge water in a closed flow-through system.)

The meter shall be calibrated in accordance with the sampling plan or, if more stringent, with the manufacturer's procedures (provided with the instrument). Any salinity adjustment shall be made to the approximate salinity of the water (one may use knowledge of the subsurface or some conductivity meters or dedicated salinity meters to obtain the salinity of the water). The probe must be thoroughly rinsed with distilled/deionized water before and after each use. Measurements shall typically be recorded to the nearest 0.1 ppm concentration.

7.3.6. Turbidity Measurements

A turbidity meter shall typically be used to make turbidity measurements on aliquots of water samples obtained just before sample acquisition. Measurements shall be made as soon as possible on the obtained aliquot. Operation and calibration shall be in accordance with the sampling plan or, if more stringent, with the manufacturer's procedures (provided with the instrument). It is preferable to have a range of calibration solutions that bracket the site turbidity range. At a minimum calibration shall be performed at the beginning and ending of each day's use and every four hours in between. Calibration shall be performed with calibration solution specified for the project. Measurements shall be recorded to the nearest 0.1 NTU when less than 1 NTU; the nearest 1 NTU when between 1 and 10 NTU; and the nearest 10 NTU when between 10 and 100 NTU.

7.3.7. Redox Potential Measurements

A meter and a flow though cell is a preferred way to measure this parameter. Alternately, a redox meter may be used to obtain redox potential measurements. However, there are many other ways to measure redox couples. When a meter is used the reading should be obtained on an aliquot of purged water that was obtained just before sampling. Measurements shall be made immediately on the obtained aliquot. (Note: The best results using a redox meter usually come from measuring the redox on the purged water in an air-space free and closed flow-through system.) Calibration and operation shall be in accordance with the sampling plan and if more stringent with the manufacturer's procedures (provided with the instrument). It is preferable to have a range of calibration solutions that bracket the site redox potential range. At a minimum calibration shall be performed at the beginning and ending of each day's use and every four hours in between. Calibration shall be performed with calibration solution specified for the project. Typically, the probe shall be thoroughly rinsed with distilled/deionized water after each sample when using a flow through cell or after each sample reading when the probe is placed in a discrete aliquot of sample. The redox using a probe shall be recorded in millivolts to the number of significant figures required by the sampling plan - which is typically three significant figures.

7.4. Capture and Disposal of Purge Water and Decontamination Solutions

7.4.1. Purge Water

Purged groundwater shall be handled as specified in the sampling plan. Typically purge water will be captured and contained in 55-gallon steel drums or suitable vessel(s). If required, each drum or tank containing captured purge water shall be properly labeled with a weather proof label as to the contents, the well(s) from which the contained purge water originated and the date in which the contents were generated. Storage of the drums or tanks shall be as specified in the project work documents or as directed by the Project Manager. In many cases there is specific wording required for the labels and this should be found in the sampling plan.

Captured and contained purge water shall be characterized for discharge, treatment and/or disposal. Characterization of the captured and contained purge water should be specified in the sampling plan or other project work documents or by the Project Manager, but could rely on site knowledge, the analytical results of groundwater samples associated with each drum or other vessel, or could involve direct sampling and analyses of the contained water.

The requirements and options available for discharge, treatment and/or disposal are dependent upon many variables such as client requirements, chemical consistency, local and state and other regulations and location of site. Discharge, treatment and/or disposal of captured and contained purge water must be in accordance with all applicable requirements such as, but not limited to, client specific procedures. Local, state and Federal regulations and shall be specified in the sampling plan or in other project work documents.

7.4.2. Decontamination Waste Solutions

Decontamination waste solutions that are generated during groundwater sampling include: spent detergent wash solutions; spent tap water rinses; any spent acid or alkali rinses, any spent organic (such as isopropyl alcohol) rinses; and spent final distilled/deionized water rinses. All decontamination waste solutions shall be captured and contained in appropriately sized vessels as required by the sampling plan or other project documentation. In any cases where this is not clear, the Project Manager shall be contacted so they can determine (with input from others as needed) whether spent decontamination solutions require capture and containment.

Captured and contained decontamination waste solutions shall be subject to requirements of the sampling plan or other project documentation. These are often generally the same guidelines as described for purge water. A noteworthy typical requirement is that all acid and alkali solutions shall be neutralized prior to discharge or disposal.

7.5. Documentation

Documentation for sampling groundwater includes labeling sample bottles; and other requirements as specified by the sampling plan or other project documentation. These further requirements often include project field notebooks, Sample Integrity Data Sheets, Field Report Forms, and Chain of Custody Records; additional documentation requirements may warrant securing individual samples or sample coolers with chain of custody seals.

7.5.1. Sample Labels

Samples shall be immediately labeled (see Exhibit A for an example label). Labels shall be water proof. Information shall be recorded on each label with indelible ink. All blanks shall be filled in (N/A if not applicable). Groundwater sample designations will be as specified in the project work documents or by the Project Manager. At a minimum the following information is required upon the label: Site name, sample ID, parameter(s) to be tested, sample date and time, sampler's initials, chemical preservative, if used.

7.5.2. Groundwater Sample Collection Forms

Groundwater Sample Collection Forms (Exhibit B) are used by the Sampling Technician to document the official raw field information for each sample that will be chemically analyzed. All blanks shall be filled in (N/A if not applicable). The original must be submitted as soon as possible to the Project Manager. Copies must be sent to the Task Leader (if appropriate).

7.5.3. Chain of Custody Records

Chain-of-Custody Records (Exhibit C) will be used to record the custody and transfer of samples in accordance with guideline TG-1.2-23, "Chain of Custody." These forms shall be filled in completely (N/A if not applicable). Tamper-proof Seals (Exhibit A) shall be placed on either sample bottles or shipping coolers. The seal number shall be recorded on the Chain of Custody Form. The original form must accompany the samples to the analytical laboratory to be completed and returned to Golder in the analytical data report. A copy of the Chain of Custody Record documenting the transfer of samples from the field must be submitted to the Project Manager.

7.5.4. Field Report Forms

Field Report Forms (Exhibit D) or project field notebooks shall be used by the Sampling Technician to record daily activities. Data shall be recorded on the Field Report Form in chronological format. The time of each recorded event shall be included. The original Field Report Form must be submitted as soon as possible to the Project Manager. Copies must be given to the Task Leader.

7.5.5. Sample Integrity Data Sheet

Sample Interity Data Sheets (Exhibit E) shall be used by the Sampling Technician to record raw field information for each sample that will be chemically analyzed. This data sheet can be used as a supplement to but not in lieu of a groundwater sample collection form. The original must be submitted as soon as possible to the Project Manager. Copies must be given to the Task Leader.

7.6. Field Change Request

Variation from established guideline requirements may be necessary due to unique circumstances encountered on individual projects. All variations from established guidelines shall be documented on Field Change Request (Exhibit F) and reviewed by the Project Manager.

In lieu of requirements in the sampling plan or other project documentation, the Project Manager may authorize individual staff to initiate variations as necessary. If practical, the request for variation must be reviewed by the Project Manager or their designee prior to implementation. All completed Field Change Requests will be maintained in project records.

8.0 REFERENCED GUIDELINES

Golder Associates Inc. Quality Procedure QP-1, "Calibration and Maintenance of Measuring and Test Equipment."

Golder Associates Inc. Technical Guideline TG-1.2-23, "Chain of Custody."

Golder Associates Inc. Technical Guideline TG-1.4-6, "Water Level Measurement."

9.0 ADDITIONAL GUIDELINES AND PROCEDURES

Wood, W.W. (1976), "Guidelines for Collection and Field Analysis of Ground-Water Samples for Selected Unstable Constituents," Techniques of Water-Resources Investigations of the United States Geological Survey, Book 1, Collection of Water Data by Direct Measurement, Chapter D2.

U.S. EPA, 1986, Test Methods for Evaluating Solid Waste - (SW-846), 3rd Edition (Final Update III, December 1996), U.S. EPA/Office of Solid Waste, Washington, D.C.

40 CFR 136, U.S. EPA, Guidelines Establishing Test Procedures for the Analysis of Pollutants. Title 40 Part 136 of the Code of Federal Regulations.

U.S. EPA, 1986, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, U.S. EPA/Office of Solid Waste, Washington D.C.

40 CFR 141, U.S. EPA, National Primary Drinking Water Regulations, Title 40, Part 141 of the Code of Federal Regulations.

Various EPA Region and State Standard Operating Procedures

Golder Associates Technical Guideline TG-2.3-3, "Headspace Analysis Using the Organic Vapor Analyzer"

TABLE 1

TABLE 1

SAMPLE CONTAINER CODES, TYPES, VOLUMES, PREPARATION,
SPECIAL HANDLING, PRESERVATION, HOLDING TIMES

Analysis	Cont. Code	Containers, Water	Handling and Preservation	Holding Time
Volatile Organics	V	2, 40ml glass vial teflon lined septum	Store 4±2°C; handle upwind from euip. Fumes, no headspace permitted; Pres with HCl to pH <2 for volatile aromatics	7 days 14 days (HCl pres.)
Base/Neutral and Acid Extractable Organics	SV	2, 1 liter amber glass, teflon lined cap	Store 4±2°C; handle upwind from equip. fumes; no contact with plastics, gloves	7 days until extraction 40 days thereafter
Organiochlroine Pesticides and PCBs	P	2, 1 liter amber glass, teflon lined cap	Store 4±2°C; handle upwind from equip. fumes; no contact with plastics, gloves	7 days until extraction 40 days thereafter
Herbicides	H	2, 1 liter amber glass, teflon lined cap	Store 4±2°C; handle upwind from equip. fumes; no contact with plastic, gloves	7 days until extraction 40 days thereafter
Total Fuel Hydrocarbons (Fuel Fingerprint)	TH	1, 125 ml amber glass, teflon lined septum	Store 4±2°C; handle upwind from equip. fumes, no headspace permitted; pres with HCl to pH <2	14 days
Total Petroleum Hydrocarbons or Oil and Grease	OG	1, 1 liter glass, teflon lined cap	Store 4±2°C; handle upwind from equip. fumes, no contact with gloves or plastics; pres with HCl to pH <2	28 days
Cyanide (total)	CN	1,1 liter plastic	Store 4±2°C; pres with NaOH to pH >12	14 days
Suflide (total)	S	1, 1 liter plastic	Store 4±2°C; pres with ZnOAC/NaOH to pH >12	7 days
Chloride, Sulfate, pH Conductivity and Total Dissolved Solids	MA	1,1 liter plastic	Store 4±2°C.	28 days (Chloride, sulfate and conductivity) Analyze on-site (pH) 7 days (TDS)

TABLE 1

SAMPLE CONTAINER CODES, TYPES, VOLUMES, PREPARATION, SPECIAL HANDLING, PRESERVATION, HOLDING TIMES,

Analysis	Cont. Code	Containers, Water	Handling and Preservation	Holding Time
Major Cations and Metals (Except Mercury)	TM	1,1 liter plastic	0.45 um filter, pres with HNO_3 to pH <2	6 months
Mercury	HG	1, 500 ml plastic	0.45 um filter, pres with HNO_3 to pH <2	28 days
Gamma Emitting Radionuclides	GR	2, 1 liter plastic	0.45 um filter, pres with HNO_3 to pH <2	6 months (record exact date/time of sampling for calculation of half-life decay)
Alpha Emitting Radionuclides	AR	2, 1 liter plastic	0.45 um filter, pres with HNO_3 to pH <2	6 months (record exact date/time of sampling for calculation of half-life decay)
Beta Emitting Radionuclides	BR	2, 1 liter plastic	0.45 um filter, pres with HNO_3 to pH <2	6 months (record exact date/time of sampling for calculation of half-life decay)
Total Phosphorus, Ammonia-N, Nitrate/nitrite-N, COD and TOC	TP	1, 1 liter plastic	Store 4±2°C; pres with H_2SO_4 to pH <2, store in dark	28 days
Orthophosphate	OP	1, 1 liter plastic	0.45 um filter, store 4±2°C	48 hours

EXHIBIT A

Golder Associates

Location ____________________

Job No. ________ Date ________

Boring No. ________ Sample No. ________

Depth ________ Blows ________

Description ____________________

Driller ________ Engr. ________

Sample Label

Golder Associates
Seal Number
2455

Golder Associates

Sent By: ________

Date: ________

Tamper Proof Seal

SAMPLE LABELS

EXHIBIT B

WATER SAMPLE FIELD INFORMATION FORM

Site:

Location:

Project Number:

Sampling Team:

Golder Associates

Sample Point ID: **(well)**

Purging Device: **Teflon Bailer & Nylon Rope**

Depth to water before purging (ft-bmp) Date: Time:

Sounded well depth (ft-bmp) PID reading (ppm)

As-built well depth (ft-bmp)

Casing diameter (in)

Casing volume (gal)

Casing Volume Calculation

2"	4"	6"	8"
0.163 gal/ft	0.653 gal/ft	1.47 gal/ft	2.61 gal/ft

Volume purged (gal) Time Start: Time Finish:

Depth to water after purging (ft-bmp) Purge Calc:

Remarks:

WELL INSPECTION (Circle Y or N)

Is well location correct on map?	Y or N	Is the well locked?	Y or N
Is well located in a dry area?	Y or N	Is the lock in good condition?	Y or N
Is well readily accessible?	Y or N	Is the well vented?	Y or N
Is well legibly labeled?	Y or N	Does casing have weep hole?	Y or N
Is well protected with posts?	Y or N	Does well have dedicated bailer?	Y or N
Is casing free of kinks/bends?	Y or N	Does well have dedicated pump?	Y or N
Is protective casing secure?	Y or N	Is equip. in good condition?	Y or N

Remarks:

FIELD MEASUREMENTS

						Units	Calibration Notes
Time	1)	2)	3)	4)	5)		
Temp.	1)	2)	3)	4)	5)	**ºC**	**Calibration time:**
pH	1)	2)	3)	4)	5)	**std. units**	**Serial#:**
Sp. Cond	1)	2)	3)	4)	5)	**mS/cm**	
Turbidity	1)	2)	3)	4)	5)	**ntu**	
D.O.	1)	2)	3)	4)	5)	**mg/l**	
Redox	1)	2)	3)	4)	5)	**mV**	
DTW	1)	2)	3)	4)	5)	**ft-bmp**	
Volume	1)	2)	3)	4)	5)	**gallons**	

Sample Collection Notes:

Weather conditions at time of sampling:

Sample characteristics:

Sample date / time: Method of sample collection: **Teflon Bailer & Nylon Rope**

Analytical Parameters:

Signature: Company: **Golder Associates Inc.** Date:

NJ Certification #03027

LOW FLOW GROUNDWATER PURGE/SAMPLE FIELD INFORMATION FORM

Golder Associates

Site ____________________

Location: ____________________

Project Number: ____________________ Meter/Type/Serial #: ____________________

MONITORING WELL ID: ____________________ Meter Calibrated @: ____________________

Depth to Water Prior to Purging [ft-bmp]: ____________________ Sampling Date/Time: ____________________

Well Casing Diameter [in]: ____________________ Sampler(s): ____________________

Start Time (purging): ____________________ Sampling Device: ____________________

Purging Device: ____________________ Sampling Purge Rate: ____________________

Pump intake setting: ____________________ Sample Characteristics: ____________________

Well Screen Interval: ____________________ PID Measurement of Well Headspace (ppm): ____________________

As-Built Construction Well Depth [ft-bmp]: ____________________ Analytical Parameters: ____________________

Sounded Well Depth [ft-bmp]: ____________________

Weather Conditions:____________________ Fe+2 result (field measurement):__________PPM

Time **[hh:mm]**	**Temperature** **[^oC]**	**pH** **[std]**	**Specific Conductance** **Circle One** **[S/m] or [mS/cm]**	**Turbidity** **[ntu]**	**Dissolved Oxygen** **[mg/l]**	**Redox Potential** **Note - Indicate if (+) or (-)** **[mV]**	**Depth To Water** **[ft-bmp]**	**Volume Purged** **[liters]**	**Approximate Purge Rate** **[ml/min]**	**Observations** (PID readings, sample characteristics, equipment problems, etc.)

Comments:

Signature:

EXHIBIT C

CHAIN OF CUSTODY RECORD

PROJ. NO.	SITE/LOCATION
SAMPLERS: *(Signature)*	

STA. NO.	DATE	TIME	SAMPLE TYPE	MEDIA	SAMPLE IDENTIFICATION	NO. OF CON-TAINERS	AMOUNT/ PRESERVATIVE						SEAL NO.	SEAL INTACT? (Y or N)	REMARKS (with initials)

Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*	Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*
Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*	Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*
Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*	Date/Time	Remarks (attachments if necessary)	

EXHIBIT D

GOLDER ASSOCIATES

DATE	JOB NO
PROJECT	
LOCATION	
CONTRACTOR	OWNER
WEATHER	TEMP °at AM °at PM
PRESENT AT SITE	

TO

THE FOLLOWING WAS NOTED.

COPIES TO

FIELD REPORT

SIGNED

EXHIBIT E

SAMPLE INTEGRITY DATA SHEET

Plant/Site ______________________ Project No. ______________

Site Location ______________________ Sample ID ______________

Sampling Location ______________________

____

Technical Procedure Reference(s) ______________________

Type of Sampler ______________________

Date ______________________ Time ______________________

Media ______________________ Station ______________________

Sample Type: grab time composite space composite

Sample Acquisition Measurements (depth, volume of static well water and purged water, etc.)

____

____

____

Sample Description ______________________

____

____

Field Measurements on Sample (pH, conductivity, etc.) ______________________

____

____

____

Aliquot Amount	Container	Preservation/Amount

Sampler (signature) ______________________ Date ______________

Supervisor (signature) ______________________ Date ______________

Golder Associates Inc.

EXHIBIT F

FIELD CHANGE REQUEST

Job/Task Number: ____________________

Procedure Reference: ____________________

Other Affected Documents: ____________________

Requested Change: ____________________

Reason for Change: ____________________

Change Requested by: ____________________ Date __________

Reviewed by: ____________________ Date __________

Project Manager

Comments: ____________________

TECHNICAL GUIDELINE FOR
GEOTECHNICAL TEST PIT LOGGING
TG-1.2-21
Rev. #0
8/24/2007

Table of Contents

List of Exhibits

1.0 PURPOSE

The purpose of this technical guideline is to establish a uniform methodology for logging and sampling of soil exposed in test pits for geotechnical and geological engineering purposes. This revision of this guideline combines and replaces Technical Procedure TP-1.3-1 Geologic Mapping of Soils Exposed in Test Pits.

2.0 APPLICABILITY

This guideline shall apply to all routine logging and sampling of test pits for geotechnical and geological engineering purposes for projects managed by Golder Associates Inc. However, Golder representatives may also use other guidelines based on client or project requirements.

3.0 DEFINITIONS

3.1. Surface Soil

Surface soil is defined as soil or fill on the land surface or as exposed by an excavation or boring within twenty (20) feet of the land surface. Various regulating agencies will often define surface soil with differing depth constraints. It is important to recognize the depth interval that is defined as surface soil for each project.

3.2. Test Pit

A test pit is a supported or nonsupported excavation created to expose, residual- , alluvial, and/or colluvial soils or fill material for in situ geologic examination, sampling, and/or testing.

3.3. Vertical Shaft

A supported excavation advanced in a vertical orientation (with depth), the purpose of which is to penetrate, examine, and test foundation soils in situ.

3.4. Test Pit Logging

Test pit logging consists of direct observation, identification, interpretation, and documentation of geologic features exposed in the vertical or near vertical walls of test pit or shaft excavations.

3.5. Geotechnical Sample

A geotechnical sample is a soil sample retrieved from a test pit or shaft excavation for purposes of physical, chemical, and/or index properties testing in support of geotechnical, environmental, and/or civil engineering investigations. When such samples support environmental remediation activities or are collected in areas known to be contaminated with hazardous wastes, a greater level of care is required to preserve and document sample identification, integrity, traceability, and in situ characteristics. Hazardous geotechnical samples are subject to the full range of chain of custody controls described in TG-1.2-23, "Chain of Custody."

4.0 DISCUSSION

Test pit logging and sampling activities are routinely performed to define subsurface site conditions for prospective engineering projects. Depending on the type of site and the purposes of the investigation, test pit logging and sampling may be the only subsurface method used, or may be used in conjunction with other methods. The logging methods discussed in this guideline are suitable only for general geotechnical and geological engineering purposes, and are not intended to provide the level of detail or documentation necessary in trench excavations (which are normally required for detailed fault analyses, for site characterization of nuclear facilities, or for other major construction projects with extensive subsurface investigation requirements). The sampling techniques described in this guideline provide the means for obtaining both disturbed and undisturbed samples for physical properties and/or index properties testing. If it is necessary to retrieve samples for chemical analysis, sampling methods shall be in compliance with TG-1.2-18, "Technical Guideline for Sampling Surface Soil for Chemical Analysis."

5.0 RESPONSIBILITIES

5.1. Field Geologist/Engineer

All Field Geologists/Engineers assigned test pit logging and sampling responsibilities are responsible for compliance with this guideline. Field Geologists/Engineers are responsible for directing the activities of their subcontracted backhoe test pit exploration or excavator operator, and for accurately and thoroughly documenting all site activities. They are responsible for verifying with the Project Manager that there are no site access restrictions and a utility locate has been performed and for following protocol established in the site Health and Safety Plan. In situations in which unexpected environmental contaminants or hazards to personnel are encountered, Field Geologists/Engineers are responsible for immediately ceasing work and notifying the Project Manager.

5.2. Project Manager

Project Managers are responsible for ensuring that all Field Geologists/Engineers assigned logging and sampling responsibilities have been properly trained in the requirements of this guideline. On the job training under the guidance of an experienced Field Geologist/Engineer is permitted at the discretion of the Project Manager, provided that the training is properly documented by a memo to file. Project Managers are responsible for: securing site access permission; conducting a utility locate; and defining the pit specifications, the required level of detail for logging, the number and type of samples to be retrieved, and the required type of physical analyses. Project Managers are also responsible for development and implementation of site specific health and safety plans for investigations at known hazardous waste sites.

6.0 EQUIPMENT AND MATERIALS

The following equipment and materials are typically used for test pit logging:

- site map with known datum information and map case;
- pocket transit (Brunton-style compass);
- tape measure;
- pocket penetrometer;
- 6 ft. engineer's folding rule;
- pit marking materials (flagging, stakes, and nails);
- standard Field Report Forms (Exhibit A);
- camera;
- hand mirror (approx. 4 inches in diameter or greater);
- WAAS-enabled Global Positioning System;
- standard Field Test Pit Log forms (Exhibit B);

- other standard field support equipment as appropriate (rock hammer, trowel, shovel, permanent marker, pen, hand lens, color chart, copy of TG-1.2-6 - Field Identification of Soil, copy of this guideline, adhesive sealing tape, etc.);
- hard hat and steel toe boots;
- Shelby tube sampler, with extra tubes, caps and wax, if required by the project; and
- plastic or cloth sample bags, sample bottles, or plastic buckets, as required.

Additional equipment required for hazardous waste sites may include:

- oxygen analyzer and organic vapor monitor;
- respirator, tyvek suit, gloves, and other personal protective gear as required by the project specific site health and safety plan or other safety directive;
- sample labels and seals (Exhibit C);
- chain of custody records (see TG-1.2-23, "Chain of Custody");
- sampling tool decontamination solutions, such as non phosphate detergent, tap water, and acetone; and
- decontamination equipment such as brushes and pressure washers, with containers for capturing waste solutions.

7.0 GUIDELINE

7.1. Utility Locate

Prior to beginning test pit excavations it is the responsibility of the Field Engineer/Geologist to check the utility locate marks to determine that no utilities exist near the test pit area.

Test pit excavations should be kept a minimum of 15 feet from buried utilities. Some larger utilities such as gas mains, fuel product lines, and most large water mains may specify greater setbacks. If utilities conflict with planned test pit locations the Project Manager should be notified to adjust the locations.

The Field Geologist/Engineer must also make note of overhead utilities such as power or phone lines, light-poles, etc. to ensure that the arm of the excavator or backhoe cannot come in contact through the full swing radius of the bucket arm.

7.2. Test Pit Location and Location Control

Location mapping shall be to the level of detail required by the applicable plan or instructions, and as appropriate, relevant and sound engineering and geologic practice. Locations shall be described by either: (1) tape measurement from three permanent features identifiable on the base map; (2) measured along a compass bearing from a permanent feature; (3) triangulated with compass bearings; (4) by GPS if of sufficient accuracy; and (5) geodetic survey using standard survey techniques in accordance with TG-1.1-2, "Geodetic Surveys." A compass may be used only when the site does not contain magnetic or large metal objects. The locations so derived will be identified by a stake marker with sample location designation. When required by project directive, location markers will be geodetically surveyed in accordance with TG-13, "Geodetic Surveys."

Test pit locations may be defined by the Project Manager, or may be defined by the Field Geologist/Engineer at the Project Manager's discretion. When the location is determined by the Field Geologist/Engineer, it is important that an appropriate and sufficient number of exposures be developed to permit development of an adequate subsurface characterization of the site. Any observed anomalies and features which may potentially constitute environmental and/or geologic hazards must be followed up in the field, and additional pits excavated as necessary. All pits should be marked with a flagged stake that has been marked with the test pit number on both sides. The stake should be located at one corner of the excavation, and should be either surveyed, located by global positioning unit, or related to a known survey point by distance measurement and compass bearing. The dimensions and compass bearing of the pit with relation to the stake must be determined. All location information shall be recorded on the Field Report form (Exhibit A), Field Test Pit Log (Exhibit B), or site location map as appropriate.

7.3. Test Pit Logging

The most detailed logging will occur in the upper 3 to 4 feet of the pit where direct access to the pit walls is possible. Below that level, the distribution of soil units shall be based on visual observation and on examination of the excavated material. **IN NO CASE SHALL GOLDER ASSOCIATES PERSONNEL ENTER AN UNSUPPORTED TEST PIT GREATER THAN 4 FEET IN DEPTH.** Excavations deeper than 4 feet may be entered only if: (1) the sidewalls of the excavation are supported; or (2) the sidewalls have been appropriately sloped or benched. On hazardous waste sites, oxygen analyzer and organic vapor analyzer scans shall be performed prior to any entry into the pit; respirator and personal protective equipment use shall be as specified by site specific health and safety plans.

The test pit or shaft stratigraphy, depth from the ground surface to the various soil units determined by a tape measure suspended from the surface, pit orientation, discernible structure and relative moisture will be recorded by the Field Engineer/Geologist in a field notebook or on the Field Test Pit Log (Exhibit B). Structural data shall be recorded by azimuth right-hand rule or by quadrants. Compasses may be used only when the pit or shaft does not contain magnetic or metal objects. Any other observed data on the nature of the material present in the sidewalls or base of the excavation such as cementation, contamination, fill debris, etc. will also be recorded. The backhoe or excavator operator may be requested to clean portions of the pit or to retrieve bucket samples from particular locations in order to aid in the recording of stratigraphy or in the collection of samples. A hand mirror used to reflect sunlight into the pit is helpful when making visual observations.

All soils shall be identified and described in compliance with TG-1.2-6, "Field Identification of Soil." The relative soil density shall be estimated, and the depth to groundwater level, if encountered, and time of observation shall be noted. Seepage shall be noted wherever encountered and an estimate of the flow rate recorded. Observations on the relative difficulties encountered by the backhoe in excavating particular materials shall be recorded, along with the relative stability of the test pit sidewalls.

7.4. Test Pit Sampling

Specific sampling requirements will be noted by the Project Manager and/or in a Field Sampling Plan or Work Plan, but the Field Engineer/Geologist will typically retrieve representative samples of each different soil type encountered during the investigation. Disturbed samples may be retrieved directly from the backhoe bucket or from within the pit using a shovel, scoop, or trowel; "undisturbed" samples may be retrieved from the excavation with a thin-walled (Shelby) tube sampler. Required sample volumes and specific considerations for particular sample types shall be specified by the Project Manager. Bulk samples shall be marked or tagged with the project number, test pit number, sample number, sampled depth interval, date, and "Golder Associates Inc." The sample number and test pit number should be marked in at least two locations as a precaution against effacement in transit to the geotechnical laboratory. Avoid labeling bucket lids only. Smaller bottled samples may be labeled with a standard Golder Associates soil sample label (see Exhibit C). Contaminated samples shall be sealed (see Exhibit C), and a chain of custody form initiated as described by TG-1.2-23, "Chain of Custody."

7.5. Equipment Decontamination

On hazardous waste sites, the backhoe bucket and all sampling equipment shall be decontaminated prior to and after use. The sampling equipment shall be cleaned with a brush or pressure sprayer and non-phosphate detergent solution, rinsed with tap water, and, if necessary, rinsed again with acetone if organic compounds are in evidence. All wash fluids shall be captured and properly disposed of as specified by the Project Manager.

7.6. Test Pit Closure/Abandonment

Unless otherwise directed by the Project Manager, all pits shall be backfilled with the excavated materials and compacted with the backhoe bucket to an acceptably safe level as determined by the Golder Engineer/Geologist after completion of all logging and sampling activities. A photo should be taken of the completed test pit and important structural or stratigraphic features prior to backfilling. A suitable reference object shall be placed in the field of view for scale and reference shall be made to the test pit number and date excavated. The photo number and test pit number should be recorded on a photo log so the photos can be labeled. The pit location stake should remain intact; if it must be moved to backfill the pit, it should be replaced, the location re-established, and recorded on the Field Test Pit Log. For safety purposes, any pit that must be left open overnight shall have its perimeter fenced and flagged, and ladder or other means of escape provided.

7.7. Field Reports

Field reports shall be produced, copied and the originals forwarded on a daily basis to the Project Manager.

7.8. Field Change Requests

Variation from established guideline requirements may be necessary due to unique circumstances encountered on individual projects. All variations from established guidelines shall be documented.

The Project Manager may authorize individual Geologist/Field Engineers to initiate variations as necessary. If practical, the request for variation shall be reviewed by the Project Manager prior to implementation. If prior review is not possible, the variation may be implemented immediately at the direction of the Geologist/Field Engineer, provided that the Project Manager is notified of the variation within 24 hours of implementation.

All completed Field Change Request forms shall be maintained in the project records.

8.0 REFERENCED GUIDELINES

Golder Associates Inc. Technical Guideline TG 1.2-6, "Field Identification of Soil."

Golder Associates Inc. Technical Guideline TG 1.2-18, "Technical Guideline for Sampling Surface Soil for Chemical Analysis."

Golder Associates Inc. Technical Guideline TG 1.2-23, "Chain of Custody."

Golder Associates Inc. Technical Guideline TG 1.1-2, "Geodetic Surveys."

EXHIBIT A

Golder Associates

DATE	JOB NO.
PROJECT	
LOCATION	
CONTRACTOR	OWNER
WEATHER	TEMP ° at AM ° at PM
PRESENT AT SITE	

TO ______________________________

THE FOLLOWING WAS NOTED:

COPIES TO ______________________________

FIELD REPORT

SIGNED ______________________________

FIELD REPORT FORM

Golder Associates Inc.

EXHIBIT B

Golder Associates

FIELD TEST PIT LOG

Temp. ________ Weather ______________________ Engineer ____________ Operator ________ Test Pit __________

Equipment ______________________________ Contractor ____________________ Date __________

Location ______________________________ Elevation ____________ Datum ________ Job __________

W ← → E

0 5 10 15 20

0
5
10
15
20

Samples	
No	Depth

Sample Descriptions and Excavation Notes	Time	Depth of Hole	Depth to W/L

Special Notes

FIELD TEST PIT LOG

REPORT OF TEST PIT: _

Golder Associates

SHEET: 1 OF 1

CLIENT:		MACHINE:
PROJECT:	SURFACE RL: m DATUM:	CONTRACTOR:
LOCATION:	PIT DEPTH:	LOGGED: DATE:
JOB NO:	BUCKET TYPE:	CHECKED: DATE:

Excavation					Sampling	Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC Symbol	SOIL / ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0									
			1									
			2									
			3									
			4									
			5									
			6									
			7									
			8									
			9									
			10									

This report of test pit must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01e
RL2

GAP6_0-BETA_YZ.GLB FULL PAGE \\ATL1-S-FS1\GOLDERATLANTA\CLIENTS\HUBER\053-3086.HOLLEY.IMPOUND\300.FIELDINFORMATION\310.SITEINVESTIGATION\310.3 TESTPIT\BLANK TEST PIT.GPJ GAP5_1.GDT 22/02/2007 10:34:39 AM

EXHIBIT C

Golder Associates

Location ____________________
Job No. ________ Date ________
Boring No. ______ Sample No. ______
Depth ________ Blows ________
Description ____________________
____
____
____
Driller ________ Engr. ________

Geotechnical Sample Label

Golder Associates Seal Number **2455**	Golder Associates	Sent By: ____________ Date: ____________

Tamper Proof Seal

SAMPLE LABELS

TECHNICAL GUIDELINE FOR
CHAIN OF CUSTODY
TG-1.2-23
Rev. #2
8/20/2009

Table of Contents

List of Exhibits

List of Figures

TG-1.2-23 Chain of Custody

1.0 PURPOSE

This technical guideline establishes the requirements for documenting and maintaining environmental sample chain of custody from point of origin to receipt of the sample at the analytical laboratory.

2.0 APPLICABILITY

When specifically invoked by project work plans, sampling plans, or QA plans, this technical guideline shall apply to all types of air, soil, water, sediment, biological, and/or core samples to be analytically tested in support of environmental investigations by Golder Associates Inc., and is applicable from the time of sample acquisition until custody of the sample is transferred to an analytical laboratory.

3.0 DEFINITIONS

3.1. Custody

Custody refers to the physical responsibility for sample integrity, handling, and/or transportation. Custody responsibilities are effectively met if the samples are:

- in the responsible individual's physical possession;
- in the responsible individual's visual range after having taken possession;
- secured by the responsible individual so that no tampering can occur; or
- secured or locked by the responsible individual in an area in which access is restricted to authorized personnel.

3.2. Chain of Custody

Chain of custody refers to the history of the physical transfer of samples between the sampler, the transporter, or carrier, and the laboratory technician. Chain of custody documentation is required as evidence that the integrity of samples was maintained during transfer.

4.0 DISCUSSION

Environmental samples must be tracked, handled and transported in a manner such that sample integrity and identification (to the location and interval at which they were obtained) is maintained. The sample custodian must maintain proper storage and custody of samples from the time of collection until transport to the laboratory. The sampler shall initiate Chain of Custody forms which accompany samples from the collection site to the laboratory and provide documentation of any transfer of custody throughout transport. Sample identification and integrity shall be ensured by the application of seals and labels to the sample containers at the time of sample collection. Seals and labels shall be verified upon receipt of samples at the analytical laboratory; unacceptable samples shall be identified on the Chain of Custody form, and referred to the Geologist/Field Engineer or Project Manager for evaluation and appropriate disposition.

5.0 RESPONSIBILITIES

5.1. Project Manager

The Project Manager is responsible for the overall management of environmental sampling activities, for designating the sample shipment method (considering permitted sample holding times), for delegating sampling responsibilities to qualified personnel, and reviewing any Field Change Requests that may be initiated during the investigation.

5.2. Geologist/Field Engineer

The Geologist/Field Engineer is responsible for: 1) providing general supervision of sampling operations as directed by the Project Manager; 2) ensuring proper temporary storage of samples and proper transportation of samples from the sampling site to the laboratory; and 3) initiating Field Change Requests when required. The Geologist/Field Engineer is also responsible for tracking Chain of Custody forms for samples to ensure timely receipt of the completed original, for reviewing Chain of Custody forms to ensure appropriate documentation of sample transfers, and for advising the Project Manager of any problems observed that are related to sample integrity and chain of custody. The Geologist/Field Engineer may delegate document tracking and review responsibilities to suitably qualified personnel.

5.3. Sampler

The sampler may be the same individual as the Geologist/Field Engineer and is responsible for: 1) sample acquisition in compliance with applicable guidelines and procedures; 2) checking sample integrity and documentation prior to transfer; 3) initiating the Chain of Custody form; 4) maintaining custody of the samples while completing the sampling project; and 5) physically transferring the samples to the transporter or directly to the laboratory.

5.4. Laboratory Sample Custodian

The laboratory sample custodian or designated sample receiving technician is responsible for: 1) inspecting transferred samples to ensure that seals are intact, that labels are affixed, that sample condition is acceptable, and that Sample Integrity Data Sheets are completed, when required for a particular project; 2) completing the Chain of Custody form upon receipt; 3)forwarding copies of the completed Chain of Custody form to the Project Manager; and 4) segregating and identifying unacceptable samples, and subsequently notifying the Golder Project Manager.

5.5. Document Custodian

The document custodian (project manager or administrative assistant) is responsible for maintaining completed Chain of Custody forms in the project files.

6.0 EQUIPMENT AND MATERIALS

- Seals and labels (Exhibit A)
- Sample Integrity Data Sheets (Exhibit B), if required by the applicable sampling procedure, work plan, sampling plan, or quality assurance (QA) plan, or if requested by the Project Manager
- Chain of Custody forms (Exhibit C)
- Field Change Request form (Exhibit D)
- Packing and shipping materials, which may include coolers or insulated packing boxes, ice, "blue ice" or dry ice, cardboard packing boxes, wooden core storage boxes, and shipping labels. If dry ice is used, caution should be used so that samples do not freeze resulting in broken jars and negative impact to other samples in the same carrier.

7.0 GUIDELINE

7.1. Seals, Labels, and Initial Storage

At the time of collection, all samples shall be sealed, labeled, and appropriately stored in the custody of the sample custodian as defined in 3.1 above. Examples of standard seals and labels are included in Exhibit A.

7.2. Sample Packaging

All samples shall be packaged appropriately for shipping to protect them from damage, to ensure that moisture content is maintained where necessary, and to ensure that appropriate temperatures are maintained as required. All sample shipping containers shall be sealed (see Exhibit A) to prevent tampering.

Environmental core sample boxing, marking, and labeling shall be in compliance with TG-1.2-2, "Geotechnical Rock Core Logging." Other types of environmental samples stored in jars or bottles may be packaged in insulated coolers, or, if sample temperature is not a concern, in the original sample container packing boxes. Where cooling is required, samples shall be shipped in insulated coolers containing bagged or pre-packaged ice sufficient to keep the samples at 4°C ± 2°. All samples should be carefully placed in the appropriate container(s) and packaged with paper or bubble-wrap to prevent significant movement or breakage during transport.

Samples from boreholes shall be packaged, where appropriate, by placing the jars in shipping containers from the top right corner downward, and from left to right, beginning with the first sample taken as shown in Figure 8-1. An alternative packaging order may be appropriate to isolate contaminated samples to minimize the risk for cross-contamination.

A label containing the following information should be affixed to the front of each shipping container containing environmental samples:

- Project Number
- Location
- Borehole number(s) (if appropriate)
- Date collected
- Sample numbers enclosed

Boxes should be numbered consecutively; the last box from a borehole or drillhole shall also be identified "EOH," (i.e., end of hole).

7.3. Sample Examination

Prior to transfer of samples, the sampler shall ensure that:

- labels and seals are affixed and completely filled out;
- Chain of Custody documentation corresponds to the samples in the shipment;
- special handling and storage requirements are identified where required;
- Sample Integrity Data Sheets are available where required by applicable sampling guidelines or the Project Manager;

- there are no indications of sample container leaks or other questionable conditions that may affect the integrity of the sample; and
- hazardous and/or radioactive samples are clearly identified as such.

Samples that do not meet the requirements for initial transfer shall be referred to the Geologist/Field Engineer or Project Manager for disposition.

7.4. Chain of Custody Form Initiation

The sampler shall initiate the Chain of Custody form (Exhibit C) for the initial transfer of samples. Chain of Custody forms supplied by the analytical laboratory may be used in lieu of the form shown in Exhibit C. At a minimum, the following information shall be entered on the form:

- the destination of the samples and the transporter or carrier;
- the project identification and sampling site;
- the date and time of sample collection;
- the sample identification numbers and descriptions (e.g., media, container);
- analysis required for samples included in the shipment; and
- QA and reporting instructions for the laboratory.

When all required information has been entered the sampler shall sign and date the Chain of Custody form as the initiator.

7.5. Transfer of Custody

To document the initial transfer of samples, the sampler relinquishing custody and the transporter accepting custody shall sign, date, and note the time of transfer on the Chain of Custody form. If the transporter is not an employee of Golder Associates Inc., the sampler may identify the carrier and reference the bill of lading number in lieu of the transporter's signature. The Chain of Custody form should be in triplicate. One copy of the Chain of Custody form shall be forwarded to the Geologist/Field Engineer by the sampler. The original form and the remaining copy shall accompany the samples.

7.6. Receipt at Destination

The laboratory sample custodian shall inspect the transferred samples to ensure that:

- the seals are intact;
- the labels are affixed and legible;
- Sample Integrity Data Sheets are available where required;
- the physical condition of the samples is acceptable; and
- the samples being transferred directly correspond to those listed on the Chain of Custody form.

If the integrity of the samples is questionable, the laboratory technician shall notify the Golder Project Manager, segregate the unacceptable samples and identify them on the Chain of Custody Form. Otherwise, the laboratory sample custodian and the transporter shall sign, date, and note the time of transfer on the Chain of Custody form. If the transporter is not an employee of Golder Associates Inc., the laboratory sample custodian may identify the carrier and reference the bill of lading number in lieu of the transporter's signature. The laboratory sample custodian shall retain the remaining copy of the Chain of Custody form and forward the original signed copy to the Geologist/Field Engineer. Appropriate laboratory custody procedures shall be initiated upon completion of transfer of custody in compliance with the laboratory's internal QA program requirements.

7.7. Document Tracking

The copy of the Chain of Custody form recording the initial transfer of samples shall be forwarded to the Geologist/Field Engineer, followed by the completed original. The Geologist/Field Engineer shall track the Chain of Custody form to ensure timely completion and receipt of the original, based on the laboratory acknowledgement due date indicated on the form and/or subcontractor agreement.

After receipt of the completed original, the Geologist/Field Engineer may discard the copy. The completed original Chain of Custody form shall be placed in the project files. Chain of Custody forms determined to be overdue or incorrectly completed shall be referred to the Project Manager for appropriate action.

7.8. Field Change Request

Variation from established guideline requirements may be necessary due to unique circumstances encountered on individual projects. All variations from established guidelines shall be documented on a Field Change Request form (Exhibit D) and reviewed by the Project Manager.

The Project Manager may authorize individual Geologist/Field Engineers to initiate necessary variations. If possible, the request for variation shall be reviewed by the Project Manager prior to implementation. If prior review is not possible, the variation may be implemented immediately at the direction of the Geologist/Field Engineer, provided that the Project Manager is notified of the variation within 24 hours of the implementation, and the Field Change Request is forwarded to the Project Manager within 2 working days of implementation. If the variation is unacceptable to either reviewer, the activity shall be redone or action shall be taken as indicated in the comments section of the reviewed Field Change Request. All completed Field Change Requests shall be maintained in project records.

8.0 REFERENCED GUIDELINES

Golder Associates Technical Guideline TG-1.2-2, "Geotechnical Rock Core Logging."

9.0 ADDITIONAL GUIDELINES AND PROCEDURES

EPA, 2002, “Standard Operating Procedure for Chain of Custody of Samples,” EPA Region 1 Office of Environmental Measurement and Evaluation, North Chelmsford, Massachusetts.

American Society for Testing and Materials, 2004. Standard Guide for Sampling Chain-of-Custody Procedures, ASTM D-4840-99(2004).

Figure 8-1

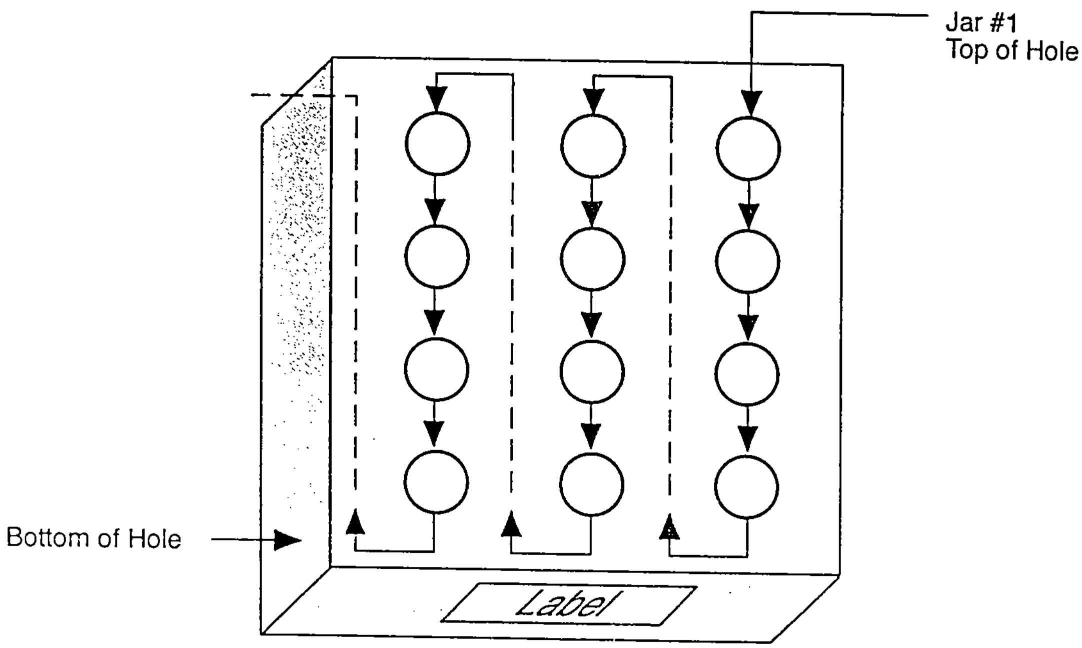


FIGURE **8-1**
SAMPLE CONTAINER PACKING ARRANGEMENT
TP-1.2-23

PROJECT NO IP3 1024.200 DRAWING NO 66972 DATE 8/15/96 DRAWN BY EA

Golder Associates

EXHIBIT A

Golder Associates

Location ____________
Job No. ______ Date ______
Boring No. ____ Sample No. ____
Depth ______ Blows ______
Description ____________

Driller ______ Engr. ______

Golder Associates

Sample I.D. No.

Date ______ Time ______
Station ______ Depth ______
Media ____________
Preservative ____________
Sampled by ____________

Golder Associates Sent By: ______
Seal Number Date: ______
2455
Golder Associates

EXHIBIT **A**
SEALS AND LABELS
TP-1.2-23

EXHIBIT B

SAMPLE INTEGRITY DATA SHEET

Plant/Site ______________________ Project No. ______________

Site Location ______________________ Sample ID ______________

Sampling Location ____

____

Technical Procedure Reference(s) ___________________________

Type of Sampler ____

Date ____________________ Time __________________________

Media ____________________ Station ________________________

Sample Type: grab time composite space composite

Sample Acquisition Measurements (depth, volume of static well water and purged water, etc.)

____

____

____

Sample Description ____

____

____

Field Measurements on Sample(pH, conductivity, etc.) ______________

____

____

____

Aliquot Amount	Container	Preservation/Amount

Sampler (signature) ____________________ Date ______________

Superviser (signature) ____________________ Date ______________

Golder Associates

EXHIBIT **B**

Sample Integrity Data Sheet

TP-1.2-23

EXHIBIT C

CHAIN OF CUSTODY RECORD

PROJ. NO.	SITE/LOCATION
SAMPLERS: *(Signature)*	

STA. NO.	DATE	TIME	SAMPLE TYPE	MEDIA	SAMPLE IDENTIFICATION	NO. OF CON-TAINERS	AMOUNT/ PRESERVATIVE						SEAL NO.	SEAL INTACT ? (Y or N)	REMARKS (with initials)

Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*	Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*
Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*	Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*
Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*	Date/Time	Remarks (attachments if necessary)	

EXHIBIT **C**

CHAIN OF CUSTODY FORM

TP-1.2-23

EXHIBIT D

FIELD CHANGE REQUEST

Golder Associates

Job/Task Number: __________

Other Affected Documents: __________

Requested Change: __________

Reason for Change: __________

Change Requested by: __________ Date __________

Reviewed by: __________ Date __________
GAI Project Manager

Comments: __________

Reviewed by: __________ Date __________
GAI QA Manager

Comments: __________

Golder Associates Inc.

EXHIBIT D

FIELD CHANGE REQUEST FORM

TP-1.2-23

PROJECT NO. IP3 1024 DRAWING NO. 67018 DATE 7/17/96 DRAWN BY CB

PROCEDURE FOR

CONSTANT HEAD HYDRAULIC CONDUCTIVITY TESTS IN SINGLE DRILL HOLES

INTRODUCTION

This procedure is under the jurisdiction of the Geotechnical Services Branch, code D-3760, Research and Laboratory Services Division, Denver Office, Denver, Colorado. The procedure is issued under the fixed designation USBR 7310. The number immediately following the designation indicates the year of acceptance or the year of last revision.

Although the term "permeability" was used in all other procedures in this manual pertaining to the capacity of rock or soil to conduct a liquid, the similar term "hydraulic conductivity," is used throughout this procedure. (See designation USBR 3900 for differences in meaning of the two terms.)

Since geologic and hydrologic conditions encountered during drilling are not always predictable and may not be ideal, variations from this procedure may be necessary to suit the particular purpose of the test, and conditions at the test site. Much of the information for this procedure was taken from references [1] through [5],[1] which contain additional information on field hydraulic conductivity testing.

1. Scope

1.1 This designation outlines the procedure for performing tests to determine an approximate value of hydraulic conductivity (permeability) of soil or rock in an isolated vertical or inclined interval of a drill hole (borehole), either above or below the water table. Usually, the tests are performed as a part of the drilling program. This procedure can be used in holes of various diameters if suitable equipment is available, but N-size [3-in (76-mm)] nominal diameter drill holes are most commonly used.[2]

1.2 The constant head, single drill hole test is based on the same theories as the steady-state or Theim-type aquifer test; and the same assumptions are made. These assumptions are: (1) the aquifer is homogeneous, isotropic, and of uniform thickness; (2) the well (test interval) fully penetrates the aquifer and receives or delivers water to the entire thickness; (3) discharge or inflow is constant and has continued for a sufficient duration for the hydraulic system to reach a steady state; and (4) flow to or from the well is horizontal, radial, and laminar. Field conditions may not meet all of these assumptions. Equations and other factors affecting the test are given in paragraph 14., *Calculations*. This procedure should not be used for testing toxic waste containment that requires a very low loss of liquid.

1.3 Constant head hydraulic conductivity tests should be considered scientific tests. Great care should be exercised by those conducting the tests to eliminate as much error as possible.

2. Auxiliary Tests

2.1 The soil or rock penetrated by the drill hole should be identified, described, and classified from samples taken during the drilling operation. Soil can be sampled in accordance with USBR 7010, 7015, or 7105 and classified in accordance with USBR 5000. Rock cores or cuttings should be examined and appropriate description and classification made. Data obtained from the drill hole should be entered on appropriate log forms.

3. Applicable Documents

3.1 *USBR Procedures*:
USBR 1040 Calibrating Pressure Gauges
USBR 1050 Calibrating Pressure Transducers
USBR 3900 Standard Definitions of Terms and Symbols Relating to Soil Mechanics
USBR 5000 Determining Unified Soil Classification (Laboratory Method)
USBR 5005 Determining Unified Soil Classification (Visual Method)
USBR 5600 Determining Permeability and Settlement of Soils [8-in (203-mm) Diameter Cylinder]
USBR 5605 Determining Permeability and Settlement of Soils Containing Gravel
USBR 7010 Performing Disturbed Soil Sampling Using Auger Boring Method
USBR 7015 Performing Penetration Resistance Testing and Sampling of Soil
USBR 7105 Performing Undisturbed Soil Sampling by Mechanical Drilling Methods
USBR 7300 Performing Field Permeability Testing by the Well Permeameter Method

[1] Number in brackets refers to the reference.
[2] Hereafter referred to as N-size holes.

3.2 *USBR Document:*

3.2.1 Geology for Designs and Specifications by the Bureau of Reclamation. (This document covers both soil and rock.)

4. Summary of Method

4.1 *Pump-In Test.*–Water is injected into an isolated interval of a drill hole in soil or rock, and the volume of water injected is determined for a measured period of time. The injection pressure is a constant gravity head, with or without added pressure head provided by a hydraulic pump. The hydraulic conductivity is calculated from the flow rate, length and radius of test interval in the drill hole, and effective head.

4.2 *Artesian Test.*–Where water under artesian pressure flows out of the drill hole, the effective (shut-in) head at the test interval is measured and the hydraulic conductivity calculated from the flow rate, the length and radius of the well, and the effective head.

5. Significance and Use

5.1 Hydraulic conductivity tests are made to obtain data related to (a) identifying seepage potential and dewatering requirements, (b) drainage problems, (c) ground-water supply investigations, and (d) grouting requirements. The tests yield approximate values of hydraulic conductivity that are suitable for many engineering purposes. Reliability of the values obtained depends primarily on (a) homogeneity of the strata tested, (b) suitability of test equipment used for a given condition, (c) care taken in performing the test, and (d) adherence to requirements for proper use of the equations. The test is also used in formulating geologic descriptions and interpretation of material properties, particularly where there is poor sample recovery.

5.2 Where tests are performed in fractured rock, results could reflect secondary conductivity rates which would not represent primary conductivity of the intact mass. When the test is performed in fractured, brittle, swelling clay or rock, or where fractures contain loose material, hydraulic conductivity may be reduced and judgment should be used in applying results.

5.3 Generally, this procedure is suitable for materials in which the hydraulic conductivity ranges between 5 and 100,000 ft/yr (5×10^{-6} and 1×10^{-1} cm/s) and where results are to be used for engineering purposes. The procedure is not applicable in materials of lower permeability, particularly for purposes such as investigations for containment of toxic wastes.

6. Terminology

6.1 Definitions are in accordance with USBR 3900. Some definitions are from *Glossary of Geology* [6].

6.2 Terms not included in USBR 3900 specific to this designation are:

6.2.1 *Drill Hole.*–A circular hole made by drilling.

6.2.2 *Feed Pipe* (conductor pipe, injection pipe, riser pipe, drop pipe).–The main pipe (or rod) which conducts water from the collar of the hole into the test interval in the drill hole for the hydraulic conductivity test.

6.2.3 *Bailer.*–A cylindrical container with a valve on the bottom for admission of fluid, attached to a line and used for recovering and removing water, cuttings, and mud from a drill hole.

6.2.4 *Walking Beam.*–An oscillating rigid lever balanced on a fulcrum used to activate the cable in cable-tool drilling by alternating up and down motion.

6.2.5 *Aquifer.*–A water-bearing bed or stratum of earth, gravel, or porous rock with interconnected openings or pores through which water can move.

6.2.6 *Packer.*–A short expansible device deliberately set in a drill hole to prevent upward or downward fluid movement; generally for temporary use. The expansible part of the packer is called the gland. Straddle packers are two packers separated by a length of perforated pipe to span or straddle a test interval.

6.2.7 *Artesian.*–An adjective referring to ground water under hydrostatic pressure; i.e., an artesian aquifer is a confined aquifer. Artesian ground water rises above the confining layer in the drill hole and may or may not flow at ground surface.

6.2.8 *Ground Water.*–That part of the subsurface water that is in the zone of saturation.

6.2.9 *Water Table.*–The surface between the zone of saturation and the zone of aeration; that surface of a body of unconfined ground water at which the pressure is equal to that of the atmosphere.

6.2.10 *Perched Water Table.*–A water table, usually of limited area, maintained above the normal free water elevation by the presence of an intervening relatively impervious confining stratum.

6.2.11 *Gauge Saver.*–A vessel, with a pressure gauge, filled with glycerin or oil to protect the gauge from direct contact with fluid in the pressure line (see fig. 1).

6.2.12 *Holding Pressure* (applicable primarily for grouting).–The gauge pressure after the water-pumping system has been shut off at the valve ahead of the gauge and backflow is prevented.

6.2.13 *Back Pressure* (applicable primarily for grouting).–The gauge pressure in the system after the holding pressure has dissipated as determined by opening a valve and allowing the gauge to drop to zero, and then reclosing the valve.

6.2.14 *Backflow* (applicable primarily for grouting).–The reverse movement of water out of the drill hole when the holding and/or back pressure below the packers exceeds the pressure of the water column in the hole.

7. Interferences

7.1 During drilling, it is important to minimize movement of fines [minus No. 200 sieve-size material (75 μm)] into the material being tested and to remove any accumulation of fines from the wall of the drill hole during preparation for the test, so as to avoid obtaining test values

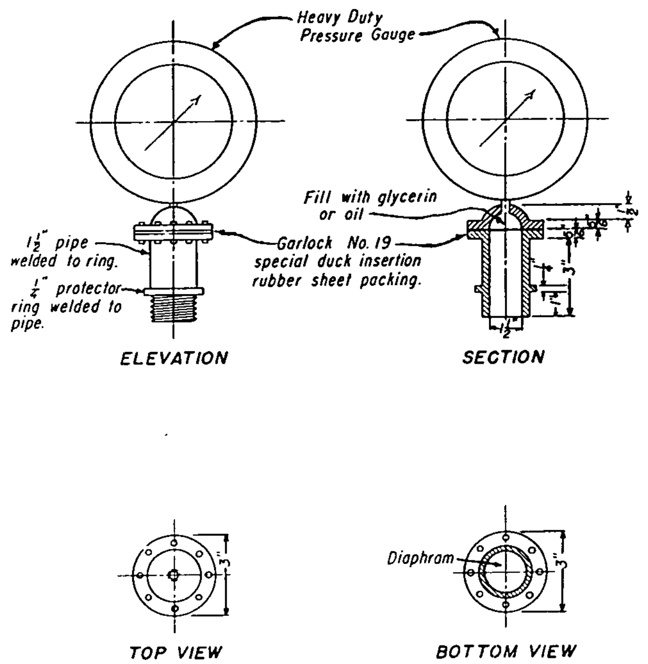


Figure 1. - Gauge saver device for protecting pressure gauge. 40-D-4287

lower than the actual hydraulic conductivity of the material being tested. Drilling using clear water without additives is preferred. Bentonitic muds should not be used in holes where hydraulic conductivity testing is to be performed. Biodegradable additives may be used if necessary, but only if the test interval is adequately cleaned before testing. The drilling procedure should be documented on the log form.

7.2 Test results can be adversely affected by injecting water containing sediment which would tend to plug voids in the material being tested.

7.3 The temperature of the injected water should be equal to or warmer than that of the ground or ground water. This reduces the tendency of air dissolved in the water to become entrapped in the voids of the material being tested and to cause low values of hydraulic conductivity. In most areas not affected by artesian conditions, the temperature at a depth of about 25 feet (8 m) below the ground surface remains relatively constant at the annual mean air temperature for the region. At significantly greater depths, temperature rises about 1 °F (0.6 °C) for each 500 to 1,000 feet (150 to 300 m) of depth. The temperature of the injected water, especially if it is known to be colder than the ground-water temperature, should be recorded on a geologic log, or the hydraulic conductivity test data forms (see subpar. 8.12 for suitable temperature measuring devices).

7.4 It is possible that dissolved minerals in the water used for a test may react chemically with substances in the material being tested to cause a change in the hydraulic conductivity. Therefore, it is desirable to use water for the test that is similar in quality to that expected to permeate the ground when the project is in operation.

8. Apparatus

8.1 *Drill Rigs* (see fig. 2):

8.1.1 *Rotary Drilling.*-A drilling method resulting in grinding a hole with a hard-toothed drill bit at the end of a rotating drill rod (pipe). The equipment consists essentially of a power unit, hoisting or tugging unit, controlled-feed rotary drill head and mounting frame, mast or tripod, and circulating pump. The rig should have various accessory drilling and sampling equipment (rods, bits, core barrels, augers), as required for drill hole advancement, sampling, and testing.

8.1.2 *Cable Tool Drilling.*-A method of drilling in which the material at the bottom of the hole is broken up by a steel bit with a blunt, chisel-shaped cutting edge. The drilling equipment consists essentially of a mast, a string of drill tools (casing, tubing, or pipe, of one size) that is alternately lifted and dropped by a hoist with a power unit, and a walking beam. A bailer is always used with a cable tool rig. Normally, a cable tool drilled hole is not satisfactory for hydraulic conductivity testing with packers.

8.2 *Injection Pump.*-A centrifugal or helical screw type pump providing a constant water flow is required. This may require a special pump separate from that used for drilling operations. Although there may be conditions where a larger or smaller pump may be required, high-quality pumps having a capacity of 40 gal/min (150 L/min) at a pressure of 120 lbf/in^2 (830 kPa) (such as Moyno model 3L-8 manufactured by the Robbins and Myers Company, Springfield, Ohio, or equivalent) are adequate for most hydraulic conductivity tests. The pump should provide the required flow at the required constant pressure with maximum allowable pressure fluctuation—due to pumping pulsations—of ± 5 percent of the test gauge pressure. A surge chamber is required for all testing; this minimizes pulsations which can affect the injection rate in the test interval. Also, it makes readings more accurate and protects the pressure gauges against damage from sudden pressure changes.

8.3 *Feed Pipe.*-The feed pipe should be of adequate diameter to minimize head losses and have adequate tensile strength to withstand pumping pressures and stresses during hoisting or tugging. The feed pipe is commonly a threaded and coupled assembly of pipe or tubing having a uniform inside diameter. Drill rods, generally of N-size, can be used without seriously affecting reliability of test data if the flow rate to the test interval does not exceed about 15 gal/min (57 L/min) and the depth to the top of the interval does not exceed 50 feet (15 m).

NOTE 1.-Use of drill rods as feed pipe should be permitted only after the assembled drill rod string has been pressure tested to calibrate head losses at anticipated flows. If seals or sealing materials are used during calibration, the same type of seals or sealing materials (not oils or wax) should be used during hydraulic conductivity testing.

8.4 *Flowmeters.*-One or more calibrated flowmeters are required; the capacity of each meter should be specified.

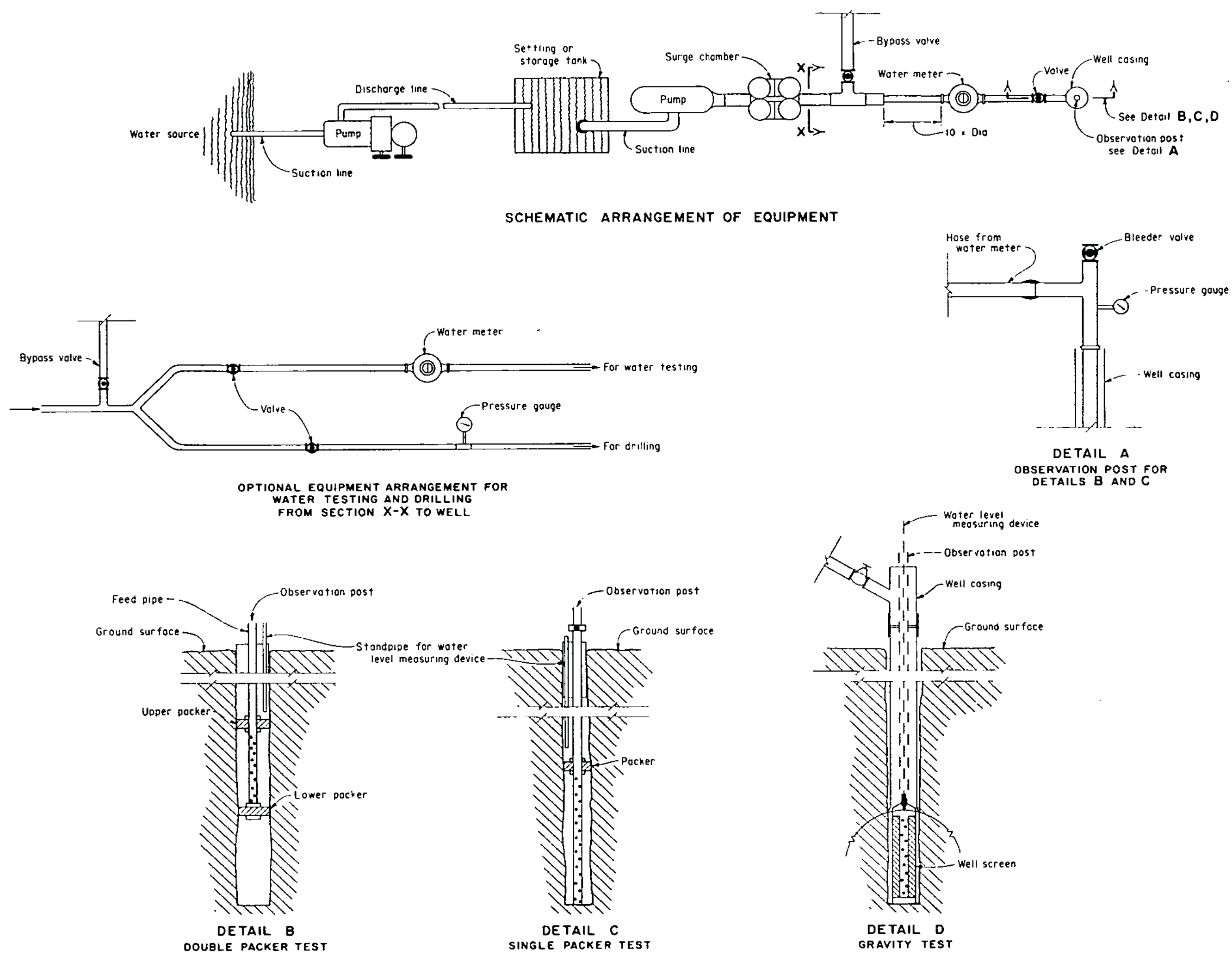


Figure 2. - Schematic arrangement of hydraulic conductivity equipment. 801-D-111

For flows up to 50 gal/min (200 L/min), a 1-inch (25-mm) diameter disk-type meter may be used. For higher flows, a 2- or 2-1/2-inch (50- or 65-mm) diameter impeller-type meter is recommended.

8.4.1 A straight uninterrupted section of pipe having an inside diameter equal to the rated size of the meter and a minimum length 10 times the inside diameter of the pipe should be provided upstream of the meter. Manufacturers commonly recommend pipe lengths of one to two times the inside diameter of straight pipe downstream from the meter.

8.5 *Pressure Sensors.*-Where required, calibrated pneumatic piezometers or electrical transducers can be used as down-hole sensors to measure pressures at the test interval during a hydraulic conductivity test. Down-hole sensors are preferred over the method of calibrating the piping system for head loss between a pressure gauge on the surface and the test interval. However, an above-ground pressure measurement can provide a check of the pressure sensor.

8.5.1 *Pneumatic Piezometers.*-A down-hole pneumatic piezometer system has been developed [7]. Descriptions of the equipment and procedure, as used at two damsites, are presented in appendix X1.

8.5.2 *Electrical Transducers.*-Electrical transducers have been used as down-hole pressure sensors by other agencies [8], particularly for very low hydraulic conductivities [below 1 ft/yr (1×10^{-6} cm/s)]. The USBR has used electrical down-hole sensors in preliminary trials. Electrical transducers measure pressures more accurately than pneumatic piezometers and can be connected to a strip-chart recorder for a continuous record. However, transducers are considered less rugged for field use and require more maintenance and experienced personnel to operate than do pneumatic piezometers.

8.6 *Pressure Gauges.*-When down-hole pressure sensors are not available or sensors are not working properly, calibrated pressure gauges can be used to estimate effective pressure in the test interval after correcting for friction loss through the feed pipe and packer. All pressure gauges used in water testing should be high-quality, stainless steel, glycerin or oil filled, with pressure indicated in both lbf/in² and kPa (such as manufactured by Marsh Instrument Company, a unit of General Signal, P O Box 1011, Skokie, Illinois; or equal). Pressure gauge ranges should be compatible with testing requirements; they should be sized so that the gauge capacity does not exceed two to three times the maximum desired pumping pressure for each respective pumping stage. Gauges should have the smallest graduations possible and an accuracy of ±2.5 percent over the total range of the gauge. If a gauge saver is used with the gauge, calibration should be made with the gauge saver in place. Accuracy of the gauges should be checked before use and periodically during the testing program (see subpar. 11.2 for additional information).

8.6.1 One or more pressure gauges should be located downstream of the flowmeter and downstream of any valves at the top of the feed pipe. This location for pressure measurement can be used by inserting a sub (adaptor, or short piece of pipe) with the gauge — installed on the top of the feed pipe.

8.6.2 At least one additional calibrated replacement gauge should be available at the test site.

8.7 *Swivel.*-During the hydraulic conductivity test, it is preferable to eliminate the swivel and use a direct connection to the feed pipe. If a swivel must be used in the water line during testing, it should be of the nonconstricting type and calibrated for head loss. Significant friction loss can result from use of the constricting type.

8.8 *Packers.*-One or two (straddle) packers are required for the test. Packers may be either bottom-set mechanical, screw set mechanical, pneumatic inflatable, or liquid inflatable. The pneumatic inflatable packer is the preferable type for general use and is usually the only one suitable for use in soft rock and soil. The gland of this packer is longer and more flexible than the other types and will form a tighter seal in an irregular drill hole. A leather cup type of packer should not be used. To ensure a tight water seal, the length of contact between each expanded packer and the drill hole wall should not be less than three times the drill hole diameter.

NOTE 2.-More than one type of packer may be required to test the complete length of a drill hole. The type of packer used depends upon many factors, e.g., rock type, drill hole roughness, spacing and width of rock joints, and test pressures.

8.8.1 *Inflatable Packers.*-Inflatable packers with an expansible gland and a floating head (see app. fig. X1.2) should be designed for anticipated drill hole diameters and pressure conditions. For normal hydraulic conductivity testing, a reasonable maximum recommended working pressure inside and outside of the packer is 300 lbf/in² (2070 kPa) [8]. Inside pressure should be increased in water-filled holes, proportionally to the static head. For drill holes with sharp projections in the walls, a wire-reinforced packer gland having a higher working pressure [7] may be required. The pressure in the packer should not be high enough to fracture the material being tested. The pressure required to form a tight seal at the ends of a test interval depends on the flexibility of the gland, the friction of the floating head, and the drill hole roughness. The minimum differential pressure between the packer and the test interval can be determined by testing packers in a pipe slightly larger than the nominal diameter of the drill hole, in order to simulate possible enlargement of the drill hole during drilling. For a given test interval pressure, the packer pressure is increased until it provides a watertight seal between the packer and the material with which it is in contact. The pressure in the packer should range approximately between 30 and 300 lbf/in² (210 to 2100 kPa) greater than that in the test interval, with 100 lbf/in² (690 kPa) being normal. Pneumatic inflatable packers can be inflated with compressed air or compressed nitrogen.

8.8.2 Special pneumatic packers are available for use in wireline drilling operations. Because the packers must be able to pass through the wireline bit and then expand to completely seal the hole at the test interval, special materials are needed for the packer gland. A special packer assembly—consisting of two packers in tandem—is used with the upper packer being expanded inside the drill rod, just above the bit, and the lower packer expanded against the wall of the hole just below the bit. The two packers on the assembly can be positioned properly—relative to the bit—by a set of lugs or a ring located on the assembly. Special seals or connections are needed to attach the water supply to the wire-line drill pipe at the surface.

8.8.3 A minimum of two sets of replacement packers and/or spare glands should be available at the test site.

8.9 *Perforated Pipe Sections.*-Lengths of perforated steel pipe corresponding to the lengths of test intervals, are required between packers to admit water into the test intervals. The total area of all perforations should be greater than five times the inside cross-sectional area of the pipe. These perforated pipe sections should be calibrated for head loss.

8.10 *Well Screen.*-Well screen or slotted pipe may be required for testing in granular, unstable materials that require support [9]. As a general rule, the maximum size of slot width should be approximately equal to the 50-percent size of the particles around the drill hole (see subpar. 11.4).

8.11 *Water Level Measuring Device*:

8.11.1 Although there are other types of water level indicators, the electrical probe indicator is most commonly used. Essentially it consists of (1) a flexible, insulated conduit marked in linear units and enclosing two wires, each insulated except at the tips; (2) a low-voltage electrical source; and (3) a light or other means of indicating a closed circuit which occurs when the tips contact the water surface. Different brands of electric water level indicators and even different models of the same brand often have their own unique operating characteristics. Before using any electric water level indicator, it should first be tested at the surface in a bucket of water.

8.11.2 For approximate measurements of the water level when it is within about 100 feet (30 m) of the ground surface, a cloth tape with a "popper" can be used. A "popper" can be made from a short pipe nipple (or length of tubing) by screwing a plug attached to a graduated tape into one end of the nipple and leaving the other end of the nipple open. When the "popper" is lowered in the drill hole and the open end of the pipe nipple strikes a water surface, it makes a popping sound, and the depth to water can be measured by the tape.

8.11.3 An accurate measurement of the water level can be made by chalking the lower end of the steel tape. After contacting the water level, the tape should be lowered about 1 more foot before retrieving it. Measurement is then made to the "wet line" on the tape.

8.12 *Temperature Measuring Device.*-Equipment for measuring ground-water temperature is available from commercial sources or can be made from a thermistor, two-conductor cable, reel, Wheatstone bridge, and a low-voltage electrical source. A maximum-minimum type thermometer is acceptable.

9. Regents and Materials

9.1 *Water* (See subpars. 7.2, 7.3, and 7.4.).-The clear water supply should be sufficient to perform the hydraulic conductivity test without interrruption and to maintain the required pressure throughout the test period.

9.2 *Sand or Gravel Backfill.*-Where a granular backfill is used to prevent sloughing of the drill hole wall, it should be a clean coarse sand or fine gravel. Laboratory permeability tests (USBR 5600 or 5605) should be made on the backfill material to make sure that it has a coefficient of permeability greater than one order of magnitude higher than that expected of the in situ material being tested.

10. Precautions

10.1 *Safety Precautions*:

10.1.1 This procedure may involve hazardous materials, operations, and equipment.

10.1.2 Use normal precautions for drilling [10, 11].

10.1.3 Precautions should be taken during calibration pressure testing of equipment, particularly testing of packers with compressed air or nitrogen (never use oxygen) to avoid injuries from a sudden packer or hose rupture.

10.2 *Technical Precautions*:

10.2.1 As a general rule, total pressure (static head plus gauge pressure) applied in the drill hole should not exceed 1 lbf/in^2 per foot (22.6 kPa/m) of rock and soil overburden at the center of the test interval, if the test interval is 10 feet (3 m) long or less. If the test interval exceeds 10 feet, pressure should not exceed 1 lbf/in^2 per foot of overburden at the top of the interval. In layered or fractured material, or for drill holes near steep abutments or slopes, 0.5 lbf/in^2 per foot (11.3 kPa/m) of material to the nearest free surface is an appropriate maximum pressure. Higher pressures than these may fracture the materials.

10.2.2 If there is excessive or complete loss of water when the hole is being drilled, drilling should be stopped before cuttings fill the voids, and a hydraulic conductivity test completed on a shorter than normal length test interval.

10.2.3 Hydraulic conductivity test equipment should be considered and treated as precision testing equipment. Gauges, thermometers, etc., should have their own protective cases; they should not be carried with drill tools or be tossed around. They should be calibrated frequently. It is recommended that all test equipment needed for hydraulic conductivity testing be kept separate from drilling equipment.

11. Calibration

11.1 *For Measurment of Effective Head*:

11.1.1 *Pressure Sensors.*-Calibrate down-hole pressure sensors by the methods and at frequencies prescribed by USBR 1050.

11.1.2 *Friction Loss Estimates.*-Where down-hole pressure sensors are not used, estimates of effective head at the test interval are made by subtracting friction loss from the applied head measured at the ground surface. The friction loss should be determined for all components of the piping system, from the pressure gauge to the test interval.

11.1.2.1 Calibrate friction loss in parts or sections of the piping systems including (1) the swivel (if used); (2) feed pipe (per unit length); and (3) the packer assembly. Record the data, with references to the particular parts calibrated, in tabular or graphical form so the accumulative friction loss can be totaled for determination of effective head at the test interval. The calibration procedure is as follows:

11.1.2.1.1 Lay out the individual or joined parts to be calibrated on a horizontal surface with calibrated pressure gauges at each end.

11.1.2.1.2 Pump water through the system at incremental, increasing flow rates to the maximum flow rate expected to be used in the test; allow the flow to stabilize between incremental flows.

11.1.2.1.3 Record the pressure at each gauge for each incremental flow rate.

11.1.2.1.4 Calculate the friction head loss for each incremental flow rate.

$$f = 2.31 \left(\frac{P_1 - P_2}{d} \right) \qquad (1)$$

where:

f = friction head loss in feet of head per linear foot of pipe, ft/ft or m/m
P_1 = upstream pressure, lbf/in^2 or kPa
P_2 = downstream pressure, lbf/in^2 or kPa
d = pipe length, ft or m (d = 1 for swivel or packer assembly)
2.31 = converts from pressure in lbf/in^2 to head in feet or 0.102 converts from pressure in kPa to head in meters

Example, assume

P_1 = 18.6 lbf/in^2 or 128 kPa
P_2 = 13.2 lbf/in^2 or 91.0 kPa
d = 10.0 ft or 3.05 m

Inch-pound application:

$$f = 2.31\left(\frac{18.6 - 13.2}{10.0}\right) = 1.25 \text{ ft/ft}$$

SI application:

$$f = 0.102\left(\frac{128 - 91.0}{3.05}\right) = 1.24 \text{ m/m}$$

11.1.2.1.5 Plot friction head loss versus flow rate. Figure 3 is an example of a plot of friction head loss (f) at relatively low flow rates for a 10-foot (3.3-m) length of 1-1/4-inch (32-mm) diameter pipe. Since head loss in pipe at turbulent flow is approximately related to velocity squared, a plot of friction head loss versus the square of the flow rate is nearly a straight line (see fig. 4).

NOTE 3.-There are standard tables and charts which provide unit friction losses for various sizes of pipe, elbows, tees, reducers, etc., for clean and rusty conditions. Although such information is sometimes used, it is preferable to determine friction losses in the piping system and packers actually used for the hydraulic conductivity test.

11.1.2.1.6 To calibrate a packer, inflate the packer in a short length of casing or pipe in which a valve and pressure gauge have been installed. A pressure gauge is also installed in the rods immediately ahead of the packer assembly. Pump water into the rods at incremental increases (or decreases) of flow rate—allowing the system to stabilize after each incremental change—until the highest anticipated flow rate is reached.

NOTE 4.-For packers smaller than N-size, such as the B-size used in wireline equipment, there are significant head losses, and relatively low flow rates must be maintained. This requires water meters and pressure gauges capable of accurately measuring the low flows and small changes in pressures.

11.2 *Pressure Gauges*.-Calibrate each pressure gauge (see USBR 1040) by comparing it with a test or master gauge. The master gauge should not be used during drilling or hydraulic conductivity testing. Calibrate each gauge at the start of a testing program plus one additional calibration per week during tests of long duration.

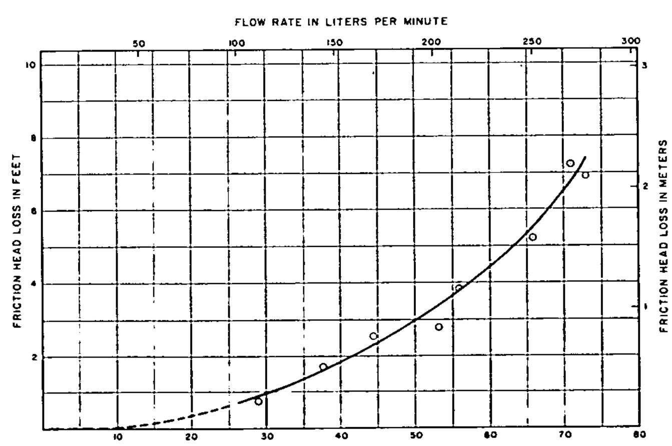


Figure 3. - Head loss due to friction at increasing flow rates for a 10-foot (3-m) 1-1/4-inch (32-mm) diameter iron pipe.

11.3 *Flowmeters*.-Calibrate a flowmeter by flowing water into a container of known volume; the container used for the volume check should be commensurate in size with the flowmeter size and graduations. From these data, flow rates can be calculated for comparison with meter readings. All flowmeters should be calibrated to an accuracy of ±1 percent. Calibration should be done at the start of the testing program plus one additional calibration per week during tests of long duration.

NOTE 5.-Some impeller-type flowmeters have an accuracy range significantly less than indicated by the dial. Minimum and maximum rates should be established.

11.4 *Well Screens and Perforated or Slotted Pipe Sections*.-From manufacturers' data or by calibration, determine the head losses in expected flow ranges to ensure there is no restriction of flow into the material being tested.

12. Conditioning

12.1 Not applicable, special conditioning requirements are not needed for this procedure.

13. Procedure

13.1 *Cleaning of Drill Hole*:

13.1.1 Remove any accumulation of fine particles (smear, mud cake, compaction caused by driving casing, etc.) from the drill hole wall. Such accumulation significantly restricts the flow of water into or from the hole. Exercise good judgment in cleaning the hole, since excess cleaning may be detrimental. If there is a question as to whether or not drill holes in particular materials need cleaning, hydraulic conductivity tests can be performed in holes with cleaning and others without cleaning. If cleaning does not significantly change test results at a site, cleaning of additional intervals in the same materials may not be necessary.

13.1.1.1 When the test interval is above the water table, it may be possible to brush or scratch the drill hole wall to break up accumulated fines. For unstable materials which require use of a well screen, materials which cave against the screen may break up the accumulation of fines on the wall. Mild surging with a bailer, while adding water, also may help break up a disturbed or compacted zone, but this may stir up fines which then plug the voids in the material to be tested. Mild jetting—followed immediately by bailing or pumping—also is a possibility.

13.1.1.2 When the test interval is below the water table—in materials that are rock-like and self-supporting—use of a water jet in the hole (preferably accompanied with pumping to induce flow into the borehole) is one of the best methods to clean the hole. After jetting, bail or pump the sediment-laden water from the test interval. Jetting can also be used through a screen below the water

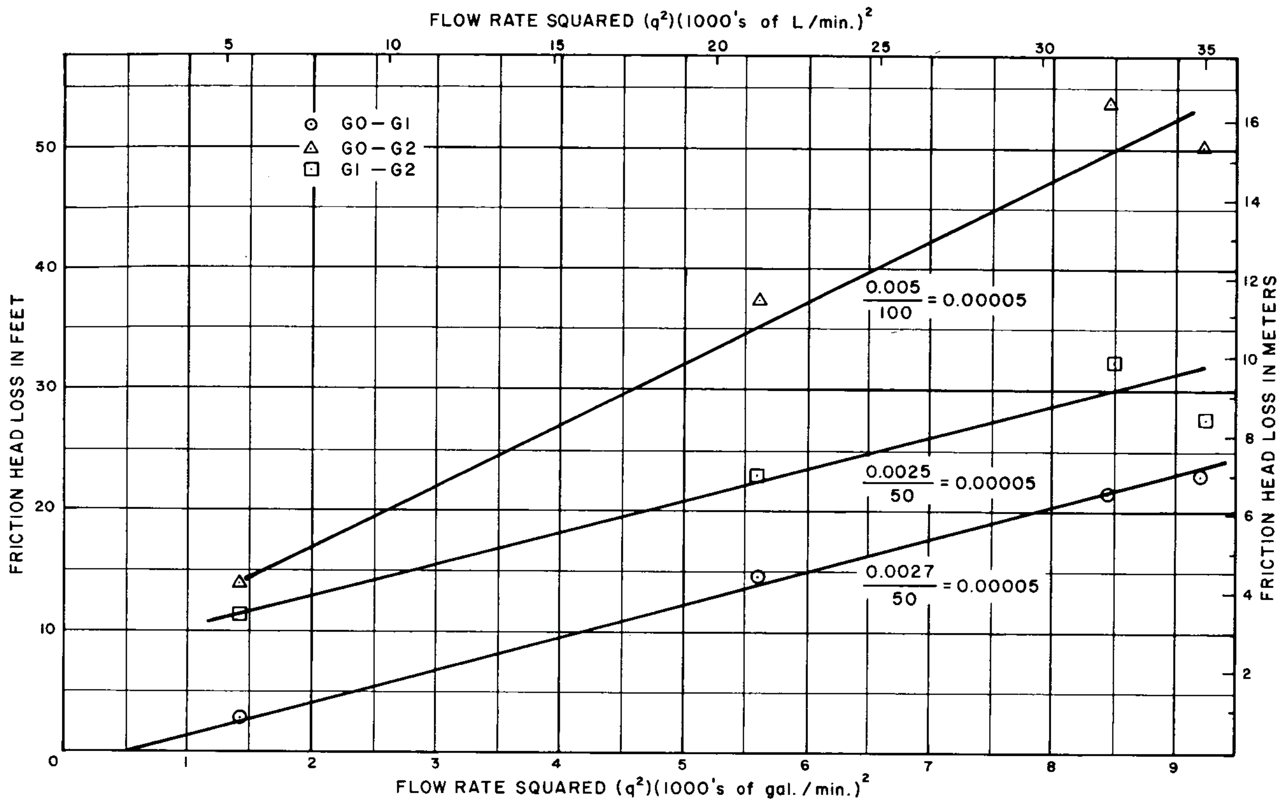


Figure 4. – Plot of feed pipe calibration data — example.

table in unstable materials. For soft rock, flushing the sides of the drill hole by running the bit or a bailer up and down the hole may enlarge the hole by erosion or otherwise change the characteristics of the fracture systems.

13.1.1.3 Finally, clean the drill hole by pumping or bailing water from the bottom upward, with the pumping continued until the return fluid is clear without cuttings or sediment. Record the method used in cleaning the hole on the log of drill hole or on a special testing form.

13.2 *Length of Test Interval*:

13.2.1 The length of the test interval depends on (1) purpose of the test, (2) stratigraphic interval, and (3) flow rate. Where materials are relatively uniform, use a test interval of about 10 feet (3 m). Where flow rates are high, shorten the test interval to locate high flow rate zones; where rates are very low, the interval may be lengthened if desired.

13.3 *Ground-Water Level Determination*:

13.3.1 Depth to ground-water level must be determined before calculating hydraulic conductivity. Measure depths to water levels with an electrical probe or other suitable equipment (see subpar. 8.11).

13.3.2 *Auger Holes*.–In power auger or other types of holes to which water is not added as part of the drilling process, report the presence or absence of a water level, depth to water level, and date of initial and final water level measurement. In materials of low hydraulic conductivity, several days to several weeks may be required for a water level to stabilize in the hole. Report evidence of moisture in the cuttings and if a perched water level was observed.

13.3.3 *Rotary or Cable Tool Holes*.–For drill holes in which addition of water to the hole is an integral part of the drilling process:

13.3.3.1 Bail or pump the hole dry or to a stable water level at the close of the last shift each day and record level.

13.3.3.2 Report the presence or absence of water and depth to water at the beginning of the first shift each day. Additional readings are desirable whenever water level in the hole has not been disturbed for an appreciable period of time.

13.3.3.3 Report changes in water level detected as the hole is drilled deeper. Record factors that affect the water level such as depth of casing, and/or cemented intervals. These data may be helpful in recognizing perched or confined (artesian) conditions.

13.3.3.4 Upon completion of the hole, the water must be bailed down to the extent practicable, the water level measured, and the date recorded of hole completion. Measure the water level for a period of days or weeks until equilibrium is reached.

NOTE 6.–At times, exceptions must be made to the requirement for continuation of water level readings. Such is the case when state or local laws require that the hole be filled continuously from bottom to top immediately upon hole completion and before the drill crew leaves the site. In other instances, landowners may allow right-of-entry for only a limited time for measurements.

13.3.4 *Perched and Artesian Aquifers.*-It is important to recognize perched and artesian aquifers, especially those under sufficient pressure to raise the water level above the confining layer but not to the ground surface (see [5]). They must be distinguished from water table aquifers (those which continue in depth). If perched water table or artesian aquifers—separated by dry or less permeable strata—are encountered in the same drill hole, the resulting water level in the hole is a composite; therefore, conclusions and interpretations based on such data are misleading. If a perched water table is recognized (or suspected) during drilling, water levels must be determined for each zone for calculation of hydraulic conductivity. This might require completion of the drill hole with a watertight seal set at a suitable horizon to separate two water table conditions. In this type installation, two strings of pipe or conduit are required: one extending down to the portion of the hole immediately above the packer, and a second string extending through the packer to a point near the bottom of the hole. Water-level measurements provide the basis for determining a perched condition or if the lower water table is under artesian pressure.

13.3.5 *Multiple Water-Level Measurements.*-In some instances, it is desirable to install multiple conduits and packers or plugs in a drill hole so that ground-water levels (or pressure heads) in several water-bearing horizons can be measured over an extended period of time (see [5], pp. 7-14).

13.4 *Pressure Tests With Packers*:

13.4.1 The recommended arrangement of typical equipment for packer pressure tests, without a pressure sensor is shown on figure 2. (See app. fig. X1.1 for equipment with a pressure sensor.) Beginning at the source of water, the general arrangement is clean water source, suction line, pump, discharge line to storage and/or settling tank, suction line, water-supply pump, surge chamber, line to bypass valve junction, water meter, gate or plug valve, tee with sub for pressure gauge, short length of pipe on which the pressure gauge is attached, tee and off-line bleeder valve for evaluating back and/or holding pressure, flexible 1-1/4-inch (32-mm) diameter hose, and 1-1/4-inch-diameter feed pipe to packer or packers in drill hole, which isolate the test interval. All connections should be tight and as short and straight as possible with minimum change in diameter of hose and pipe. Friction loss decreases as the pipe diameter is increased.

13.4.2 When the material is subject to caving, and casing and/or grout is needed to support the walls of the drill hole, the hole should be water tested as it is advanced. Other hole conditions may make this procedure desirable or necessary. The following procedure is commonly used:

13.4.2.1 After the hole has been drilled to the top of the interval to be tested, it may be desirable to remove the drill string from the hole and advance casing or grout to the bottom of the hole.

13.4.2.2 Advance the hole 5 to 10 feet (1.5 to 3 m) into the material to be tested.

13.4.2.3 Remove the drill string from the hole.

13.4.2.4 Clean the interval to be tested, and record the depth to the water table, if present. If a composite water level is suspected, the water level affecting the test should be determined by measurements through the feed pipe after the packer has been seated and the water level has stabilized.

13.4.2.5 If the hole will stand open, seat a single packer at the top of the test interval. Record the type of packer, its depth, and packer pressure if it is the inflatable type.

13.4.2.6 Pump water into the interval at a rate to develop a suitable pressure. The pressure to be used depends upon testing depths and ground water levels or pressures. Materials subject to deformation or heaving, such as by separation of bedding planes or joints, or materials at shallow depths, must not be subjected to high pressures (see subpar. 10.2.1). For comparison of flow rates in different parts of a single foundation and with results from other foundations, some of the following pressures are commonly used: 25, 50, 75, and 100 lbf/in^2 (170, 350, 520, and 690 kPa).

NOTE 7.-At test pressures less than 25 lbf/in^2, errors in measurement of pressure and volume of water may increase unless special low pressure gauges are used. Gravity tests provide more accurate results under these conditions. At pressures higher than 10 lbf/in^2, difficulties in securing a tight packer seal and the likelihood of leakage increase rapidly. However, under artesian pressures or in deep holes the water pressure—as registered on a surface gauge—will need to be sufficient to overcome the effective head at the test interval and firmly seal the packer.

NOTE 8.-Where the hole is subject to caving, a pump-down wire-line system has been developed that can be used to eliminate removal of the drill string from the hole. With this system, the hole is drilled to the bottom of the interval to be tested, and the drill rod is raised so the end of the rod is at the top of the test interval. The tandem packer (see subpar. 8.8.2) is then lowered through the drill rod and expanded to seal both inside the rod and against the wall of the hole at the top of the test interval. Models of this equipment are available which have transducers below the packer for measuring water pressures at the test interval.

13.4.2.7 For determining effective head, artesian heads encountered in the drill hole are treated the same as water table conditions; i.e., the depth from the pressure gauge, or the water level maintained during the test, to the stabilized water level is used as the gravity head. If the artesian head stabilizes above the ground surface, the gravity component of the effective head is negative and is measured between the stabilized level and the pressure gauge height. If a flow-type test is used, the effective head is the difference between the stabilized water level and the level maintained during the flow period.

13.4.2.8 After pressures are selected, based on ground-water conditions and the purpose of the test, perform a test at each pressure. Usually, a 5-cycle procedure is used, three increasing steps to the maximum pressure and then two decreasing steps to the starting pressure. This cycling allows a more detailed evaluation of test results than testing at a single pressure and commonly allows extrapolation to ascertain at what pressures the following may occur (1) laminar flow, (2) turbulent flow, (3) dilation of fractures, (4) washouts, (5) void filling, or (6) hydraulic fracturing. However, the equations normally used to calculate hydraulic conductivity are based on laminar flow conditions.

NOTE 9.–In some instances, only a single water pressure test at a given interval in the drill hole may be required. For example, if geologic conditions are known, and there is no need to perform the steps in subparagraphs 13.4.2.2 through 13.4.2.6, a single value of hydraulic conductivity with a relatively low application of pressure may suffice.

13.4.2.9 During each test, continue pumping water to the test interval at the required pressure until the flow rate becomes stable. As a general guide, maintain flow rates during three or more 5-minute intervals during which 1-minute readings of flow are made and recorded. In tests above the water table, water should be applied to the test interval until the flow rate stabilizes before starting the 5-minute measurement intervals. Where tests are below the water table, flow rates usually stabilize faster than for the tests above the water table, and the time period before the 5-minute test intervals may be shorter. These time periods may need to be varied, particularly when tests to determine grouting requirements are made

13.4.2.10 Determine and record the presence of back pressure and decay of holding pressure. After the test, deflate the packer and remove it from the drill hole.

13.4.2.11 Advance the drill hole and, if necessary, the casing; repeat the procedure in subparagraphs 13.4.2.3 through 13.4.2.10 until the required depth of drill hole is reached. When casing is used in a drill hole, always set the packer in the material below the casing.

13.4.3 If the hole will stay open without casing, it can be drilled to final depth, and after cleaning the hole, hydraulic conductivity tests can be performed from the bottom of the hole upward using straddle (double) packers. Although a single packer can be used to test the bottom interval of the hole, starting at the bottom with double packers will cause loss of borehole testing of only about the length of the bottom packer and will save one complete trip in and out of the hole with the drill string assembly to change the packers. After the test for the bottom interval is completed, straddle packers are used for successive test intervals up the drill hole. See subparagraph 13.4.2, where caving or other hole conditions will not allow this procedure.

13.5 *Gravity Tests*:

13.5.1 Constant-head gravity tests are usually performed without packers above or below the water table with drill holes of N-size or larger (see fig. 2, detail D). This type of test is often made in reasonably stable-walled drill holes up to 25 feet (7.6 m) depth where water pressure at the test interval needs to be kept low. The test is usually performed in successive 5- or 10-foot (1.5- or 3-m) intervals as the drill hole is advanced. The upper end of each test interval is normally determined by the bottom depth of tightly reamed or driven casing. If the casing is not believed to be tight, appropriate entries should be recorded on the log form. If the wall of the drill hole is stable, the test can be performed in the unsupported hole. If the wall needs to be supported, use a well screen (see subpar. 11.4 for calibration) inserted through the casing. It may be necessary to ream or drive the casing to the bottom of the interval, set the screen, and then pull back the casing to expose the screen. After the test, the screen is removed and the casing reamed or driven to the bottom of the hole.

NOTE 10.–Clean coarse sand or fine gravel backfill (see subpar. 9.2) may be used instead of a well screen. Ream or drive the casing to the bottom of the interval, clean it out, and add the backfill as the casing is pulled back to expose the test interval. Record use of this procedure on the log form.

13.5.1.1 If the drill hole is self-supporting, clean and prepare it in the normal manner (see subpar. 13.1).

13.5.1.2 If the drill hole is not self-supporting, lower the well screen and casing into the hole.

13.5.1.3 For test intervals above the water table, maintain a constant head of water [within 0.2 foot (60 mm)] at the top of the test interval by injecting water through a small diameter tube extending below the water level maintained during the test. For test intervals below the water table or influenced by artesian conditions, maintain a constant head a short distance above the measured static water level.

Monitor the water level with a water-level indicator. If the water-level indicator is inserted in a small diameter pipe in the casing, the wave or ripple action on the water surface will be dampened and permit more accurate water-level measurements.

NOTE 11.–When the flow rate is very low, the constant water level can be maintained by pouring water in the hole from a graduated container.

13.5.1.4 Record the flow rate at time intervals until a constant flow rate is reached.

13.5.1.5 Repeat the procedure of subparagraphs 13.5.1.3 and 13.5.1.4 at one or more different water levels.

13.5.1.6 This test is essentially the same as designation USBR 7300 (see also [3], p. 74); the instructions in USBR 7300 for performing the test and calculating hydraulic conductivity apply to this procedure also.

14. Calculations

14.1 For pressure or constant gravity head hydraulic conductivity tests, calculate the hydraulic conductivity of the soil or rock by the following equation (expressed in consistent units) [4]:

$$k = \frac{q}{2\pi LH} \ln \frac{L}{r}, \text{ where } L \geqq 10r \tag{2}$$

or

$$k = \frac{q}{2\pi LH} \sinh^{-1} \frac{L}{2r}, \text{ where } 10r \geqq L \geqq r \tag{3}$$

where:

k = hydraulic conductivity, ft/yr or cm/s
q = constant rate of flow into the test interval, ft^3/yr or cm^3/s
L = length of the test interval, ft or cm
H = differential head of water at test interval, ft or cm
r = radius of the borehole, ft or cm
ln = natural logarithm, $\log_e$
$\sinh^{-1}$ = inverse hyperbolic sine, $\sinh^{-1} x \ln (x + \sqrt{x^2 + 1})$

14.2 An example calculation for a single packer test in the bottom of a borehole below the water table follows:

Example, assume:

$$r = 1.8 \text{ in or } 0.15 \text{ ft} = 4.6 \text{ cm}$$
$$q = 2.2 \text{ gal/min or } 8.3 \text{ L/min}$$
$$q = 1.5 \times 10^5 \text{ ft}^3/\text{yr} = 140 \text{ cm}^3/\text{s}$$
$$L = 3.0 \text{ ft} = 91 \text{ cm}$$
$$H_g, \text{ gravity} = \text{distance from ground-water level to pressure gauge} = 10.2 \text{ ft} = 311 \text{ cm}$$
$$H_p, \text{ pressure} = 5 \text{ lbf/in}^2 \times 2.31 \text{ ft}_{water}/(\text{lbf/in}^2)$$
$$= 11.6 \text{ ft} = 354 \text{ cm of water}$$
$$H = H_g + H_p = 21.8 \text{ ft} = 664 \text{ cm}$$
$$\frac{L}{r} = \frac{3.0}{0.15} = 20, \text{ hence use equation (2):}$$
$$k = \frac{q}{2\pi LH} \ln \frac{L}{r}$$
$$k = \frac{1.5 \times 10^5 \text{ ft}^3/\text{yr}}{2\pi (3.0 \text{ ft}) 21.8 \text{ ft}} \ln \frac{3.0 \text{ ft}}{0.15 \text{ ft}}$$
$$k = 1.1 \times 10^3 \text{ ft/yr} = 1.1 \times 10^{-3} \text{ cm/s}$$

NOTE 12.–These equations are most applicable and reliable where the length of test interval is at least $5r$, and the interval is below the water table. The equations are based on laminar flow of fluid through porous media. Flow rates, high enough to cause turbulent flow, invalidate the results in all types of material. In fractured material, the calculated value should be considered an apparent hydraulic conductivity even under laminar flow conditions.

14.3 For pressure tests, when the test interval is below the water table, H is the distance from the water table to the elevation of the pressure gauge plus applied pressure converted to linear units of water head.

Where the test interval is above the water table, H is the distance from the midpoint of the isolated test interval to the elevation of the pressure gauge plus the applied pressure converted to linear units of water head.

For gravity tests above the water table, H is the distance between the bottom of the test interval and the water level maintained during the test.

For gravity tests below the water table, H is the distance between the pretest stabilized water level in the drill hole and the water level maintained during the test.

14.4 If there is artesian pressure, an additional pressure must be applied to overcome the artesian pressure to provide an effective test pressure. For example, if there is an artesian pressure of 5 lbf/in^2 (34 kPa) at the pressure gauge, 15 lbf/in^2 (103 kPa) could be applied, then the effective pressure would be 15 lbf/in^2 minus 5 lbf/in^2 which equals 10 lbf/in^2 (69 kPa).

14.5 The calculations can be done conveniently by (1) a nomograph [12], (2) a hand calculator with the proper functions, or (3) a computer. For repeated tests, it is convenient to prepare a table for one or more diameter drill holes and lengths of test intervals and combine the terms on the right side of the equations, other than q and H, into a coefficient.

NOTE 13.–The lugeon (lugeon unit, lugeon coefficient) [13, 14, 15, 16], has been used as an index of hydraulic conductivity, in connection with cyclic tests, and for grouting purposes.

15. Report

15.1 Record field test data on a daily driller's report, and/or on the log of the drill hole or on a special reporting form designed for the specific project. Record the following:

15.1.1 Log of the drill hole.

15.1.2 Elevations of the ground surface, the water table, and the top and bottom of the test interval.

15.1.3 Diameter of the drill hole at test interval.

15.1.4 Method of cleaning the drill hole.

15.1.5 Size of the feed pipe and any well screen.

15.1.6 Water pressure and/or gravity head, and flow rate for each time interval.

15.1.7 Total amount of water used per test.

15.1.8 Average temperature of ground water and water used in the test.

15.1.9 Packer inflation pressures.

15.1.10 Capacity of pump supplying water to the test interval.

15.1.11 All head loss calibration data.

15.1.12 Note any comments considered necessary to help evaluate the test results.

15. References

[1] "Permeability Tests Using Drill Holes and Wells," Bureau of Reclamation Geology Report No. G-97, Denver, Colorado, January 3, 1951.

[2] *Ground Water Manual*, 1st ed., rev. reprint, Bureau of Reclamation, U.S. Government Printing Office, Washington, D.C., 1981.

[3] *Drainage Manual,* 1st ed., 2d print., Bureau of Reclamation, U.S. Government Printing Office, Washington, D.C., 1981 1984.

[4] Zangar, Carl N., *Theory and Problems of Water Percolation*, Engineering Monograph No. 8, Bureau of Reclamation, Denver, Colorado, 1953.

[5] *Drill Hole Water Tests*, Technical Instructions–Provisional, Engineering Geology, Bureau of Reclamation, July 1970 (unpublished).

[6] *Glossary of Geology*, 2d ed., American Geological Institute, Falls Church, Virginia, 1980.

[7] Hatcher, R. C., "High Pressure Inflatable Packer with Pneumatic Piezometer," Bureau of Reclamation Report GR-10-75, Denver, Colorado, October 1975.

[8] Bennett, R. D. and R. F. Anderson, "New Pressure Test for Determining Coefficient of Permeability of Rock Masses," Technical Report GL-82-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 1982.

[9] *Ground Water and Wells*, A Reference Book for the Water-well Industry, 1st ed., published by Edward E. Johnson, Inc., Saint Paul, Minnesota, 1966.

[10] *Driller's Safety Manual,* 1st ed., reprint, Bureau of Reclamation, Denver, Colorado, 1982.

[11] Acker, W. L., III, *Basic Procedures for Soil Sampling and Core Drilling*, published by the Acker Drilling Company, Scranton, Pennsylvania, 1974.

[12] *Underground Mining Methods Handbook* No. 580, W-88, Society of Mining Engineers, Littleton, Colorado, p. 62, 1982.

[13] Lugeon, M., "Barrages et Geologie Dunod, Paris," 1933.

[14] Houlsby, A. C., "Routine Interpretation of the Lugeon Water-Test," Quarterly Journal, Engineering Geology, vol. 9, pp. 303-313, 1976.

[15] Heitfeld, K. H., and L. Krapp, "The Problem of Water Permeability in Dam Geology," Bull. International Association of Engineering Geology, No. 23, pp. 79-83, 1981.

[16] Pearson, R. and M. S. Money, "Improvements in the Lugeon or Packer Permeability Test," Quarterly Journal, Engineering Geology, vol. 10, the Netherlands, pp. 221-239, 1977.

APPENDIX

X1. PROCEDURE USING A PNEUMATIC PIEZOMETER WITH TWO PACKERS ISOLATING THE TEST INTERVAL

X1.1 Equipment Assembly (Refer to figs. X1.1 and X1.2).–A complete straddle packer unit is assembled as follows.

X1.1.1 Connect a predetermined length of perforated injection (feed) pipe to the lower packer. (The length of perforated pipe is determined by the thickness of the zone to be tested.) Connect the inflation tubing to the lower packer, and lower the sliding head end of the packer into the drill hole. (See subpar. 11.1.2.1.6 for calibration of packers.)

X1.1.2 Clamp the top of the perforated injection pipe at the hole collar, and connect the upper packer with the sliding head already down the hole.

X1.1.3 Provide approximately 12 inches (300 mm) of slack in the inflation tubing between the two packers to allow for retraction of the upper packer sliding head. Connect the tubing to the upper packer.

X1.1.4 Install the pneumatic piezometer, piezometer tubing, packer inflation tubing, and sealed lengths of injection pipe to the head adaptor.

X1.1.5 Lower the entire unit into the drill hole adding lengths of sealed injection pipe as necessary to reach the interval to be tested. As the unit is lowered, the packer inflation tubing and the piezometer tubing is unreeled into the hole and taped to the sealed injection pipe at approximately 10-foot intervals.

X1.1.6 Upon reaching the test depth, lock both the inflation tubing reel and the piezometer tubing reel; connect the inflation tubing by quick-connect couplings to a nitrogen or compressed air bottle equipped with a high pressure regulator; connect the piezometer tubing by quick-connect couplings to the readout box; and connect the injection pipe to the water pressure source. The test is now ready to begin.

X1.2 Test Procedure

X1.2.1 After the unit has been lowered to the test interval and before inflating the packers, any water head above the test interval must be determined. This head will show as pressure on the pneumatic piezometer gauge and can be verified by running a water level indicator into the hole to measure the depth to the water table. The piezometer will register water pressure that can be converted to head of water. This water head should be

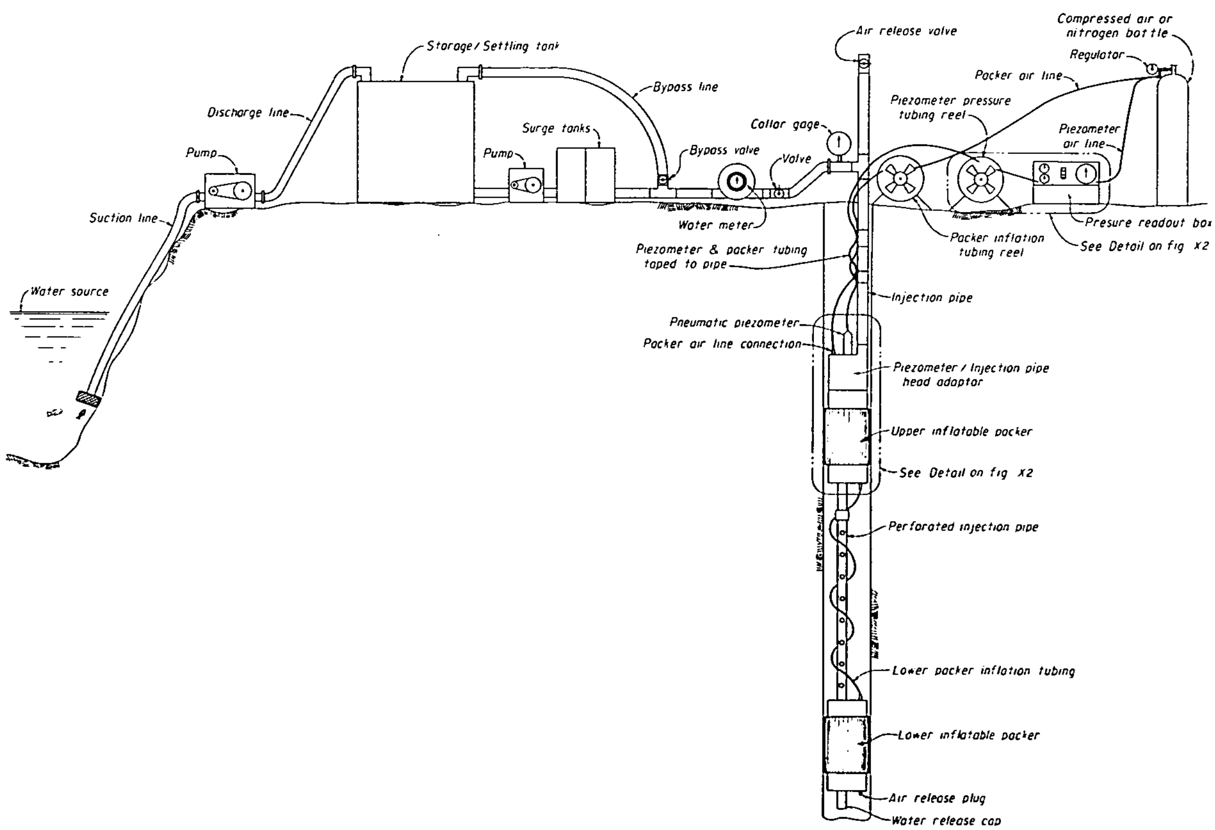


Figure X1.1. - Schematic arrangement of drill hole packer and pressure monitoring equipment. 801-D-180

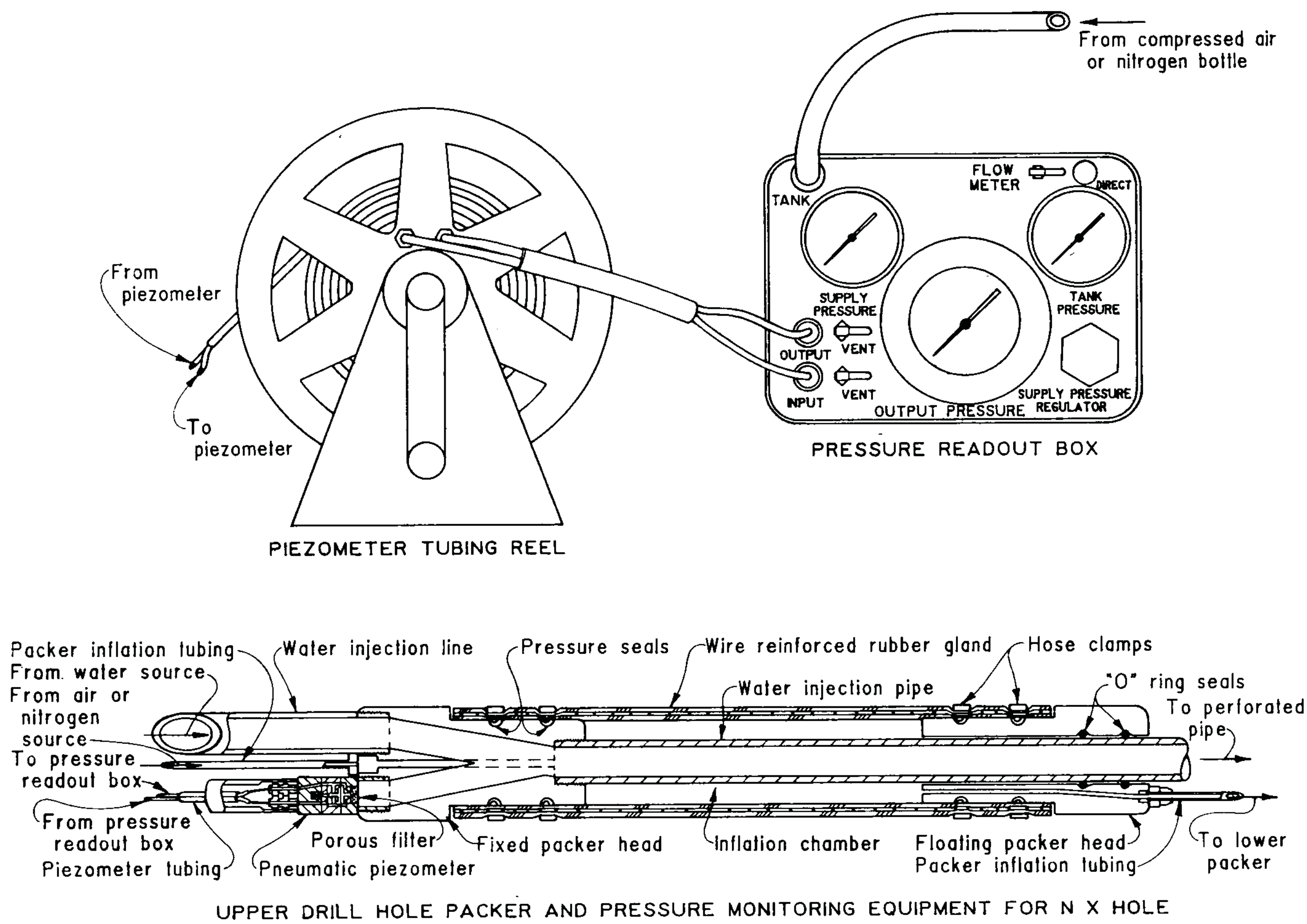


Figure X1.2. - Upper drill hole packer and pressure monitoring equipment for NX hole.

used to determine the minimum inflation pressure to be applied to the packers by the following equation:

$$SH + PP + PE = \text{minimum inflation pressure}$$

where:

SH = static pressure at the midpoint elevation of the test interval, $\mathrm{lbf/in^2}$ or kPa

PP = gauge pressure to be maintained during the test, $\mathrm{lbf/in^2}$ or kPa

PE = pressure needed to expand packer to hole diameter as determined before insertion in the drill hole by expanding the packer in a length of pipe having a diameter similar to the hole diameter, $\mathrm{lbf/in^2}$ or kPa

Inflation pressure gauge is in units of $\mathrm{lbf/in^2}$ (kPa).

The static water level measured before the packers are inflated might be a composite water level (see subpar. 13.3.4).

X1.2.2 Inflate the packers, and determine water head for the test interval. This is the static head to be used for calculation of hydraulic conductivity. If the static head is significantly different from the composite measured before the packers were inflated, recalculation of packer inflation pressure may be required. The final packer inflation pressure should be the lowest practical pressure to seal the test interval against the maximum injection pressure to avoid fracturing of the material being tested.

X1.2.3 After the inflation pressures have been determined, deflate the packers; fill and flush the system with water until all entrapped air has been removed. This is accomplished by filling the injection pipe under a gravity head and leaving the air-release valve open at the top of the injection pipe tee at an elevation higher than the injection hose. The valve must remain open until all air has been removed and water runs freely, indicating a filled system. At this point, water is flowing around the deflated packer system and is completely filling the annulus between the drillhole and the packers. In the case of an interval with a high injection rate, it may be necessary to keep the air valve closed to keep from entraining air into the test interval.

X1.2.4 Close the air release valve at the top of the injection pipe and slowly inflate the packers to the predetermined inflation pressure.

X1.2.5 Lock in the inflation pressure by closing the pressure valve in the packer tubing. If the pressure gauge on the closed system remains steady, it verifies a sealed system. At this point, water injected under gravity head approaches a constant flow rate.

X1.2.6 Record the piezometer pressure after packer inflation. For an interval of very low injection rate, this is equal to the height of the injection standpipe plus the pressure recorded at the hole collar gauge. For a test interval with a high injection rate, the readout would show the same value less any friction from water flow through the injection pipe.

X1.2.7 Proceed with the test by applying the selected pressures at the test interval and monitoring the flow rate and pressure on the pneumatic piezometer.

X1.2.8 To accurately compute hydraulic conductivity, the down-hole pressure must remain constant. A zone with a high injection rate must be monitored more closely than a zone with a small injection rate, and adjustments made to hold the down-hole pressure constant. To accomplish this, the injection pressure shown on the collar gauge must be adjusted in order to maintain the down-hole pressure constant.

NOTE X1.–For example, a pressure stage is started with the collar gauge reading 35 lbf/in^2 (241 kPa) and the down-hole piezometer reading 200 lbf/in^2 (1380 kPa). As the flow increases, the down-hole pressure may drop to 150 lbf/in^2 (1034 kPa) because friction loss in the injection pipe and the collar gauge would have to be adjusted to bring the down-hole pressure gauge back up to 200 lbf/in^2. When the flow decreases from a fast to a slow rate, the collar gauge pressure would have to be decreased.

X1.2.9 The test is completed following one or more stages of pressure increases and pressure decreases. Following the last stage, deflate the packers and close the injection line. The system is now ready to move to the next test interval for repetition of this procedure.

APPENDIX C
QUALITY ASSURANCE PROJECT PLAN FOR GROUNDWATER AND SURFACE WATER SAMPLING

REPORT

DRAFT

QUALITY ASSURANCE PROJECT PLAN FOR GROUNDWATER AND SURFACE WATER SAMPLING

Monsanto Soda Springs Facility, Soda Springs, Idaho

Submitted To: Monsanto Company
Soda Springs Plant
Highway 34
Soda Springs, Idaho 83276

Submitted By: Golder Associates Inc.
18300 NE Union Hill Road, Suite 200
Redmond, WA 98052 USA

Distribution:

3	Copies	Monsanto, Soda Springs, Idaho
1	Copy	EPA Region X, Seattle, Washington
1	Copy	IDEQ-Pocatello, Idaho
1	Copy	CH2M-Hill, Boise, Idaho
2	Copies	Golder Associates Inc., Redmond, Washington

July 24, 2013 **913-1101.-002.002.2A**

A world of capabilities delivered locally

Golder Associates

Table of Contents

List of Tables

List of Acronyms and Abbreviations

Item	Definition
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRP	Conservation Reserve Program
HASP	Health and Safety Plan
IAC	Idaho Administrative Code
IC	Institutional Control
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality
IDWR	Idaho Department of Water Resources
ISM	Incremental Sampling Methodology
INW	Instrumentation Northwest
NELAP	National Environmental Laboratory Accreditation Program
pCi/g	Picocuries per Gram
QAPP	Quality Assurance Project Plan
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SEM	Scanning Electron Microscopy
SPLP	Synthetic Precipitation Leaching Procedure
TCLP	Toxicity Characteristic Leaching Procedure
UBZ	Upper Basalt Zone
USBR	US Bureau of Reclamation
USEPA	US Environmental Protection Agency

1.0 PROJECT DESCRIPTION

1.1 Project Objective and Historical Background

This Quality Assurance Project Plan (QAPP) has been written to support specific procedures, analytical methods, and other detailed instructions performed in conjunction with elements of the “Groundwater and Surface Water Sampling and Monitoring Plan” (Golder 2012) and the “Draft Work Plan for Upper Basalt Zone 2 (UBZ-2) Phase 2 - Source Area Field Investigations (Golder 2013). The QAPP was generated in significant accordance with the document EPA QA/R-5, ‘EPA Guidance for Quality Assurance Project Plans’ (USEPA 2002a) and provides procedures for making accurate measurements and obtaining representative, accurate, and precise analytical data. Work plan tasks include sampling of monitoring wells, springs, non-contact cooling water, and surface water.

1.2 Site Description

A discussion of the Monsanto Soda Springs site is provided in the Phase II Remedial Investigation Report for the Soda Springs Elemental Phosphorus Plant (Golder 1995).

2.0 PROJECT ORGANIZATION

2.1 Organizational Structure

Project directors and their contact information are provided in the table below. The organizational structure for field activities for the Monsanto Soda Springs site is provided in the following paragraphs.

	Golder Project Manager	Monsanto Project Coordinator
Contact:	David Banton	Jim McCulloch
Company:	Golder Associates Inc.	Monsanto Chemical Company
Address:	18300 NE Union Hill Road, Suite 200 Redmond, Washington 98052-3333	PO Box 816 Soda Springs, Idaho 83276
Phone:	(425) 883-0777 Work (425) 503-9331 (cell)	(208) 547-1233
Facsimile:	(425) 882-5498	(208) 547-3312

Project Manager & Quality Assurance Coordinator

The Project Manager, Mr. David Banton from Golder Associates Inc. (Golder) is responsible for planning and executing all environmental sampling and analysis and for preparation of analytical data reports, and all associated Technical memoranda including submittals to the Idaho Department of Environmental Quality (IDEQ) and the US Environmental Protection Agency (USEPA). The Project Manager prepares the specifications for, and administers the subcontracts for laboratory analysis. Mr. Banton also acts as the Quality Assurance Coordinator and, at his discretion, reviews aspects of quality control or directs Golder technical staff to perform tasks to determine if data quality objectives are being met.

Groundwater and Surface Water Sampling and Monitoring Plan Coordinator and Site Health & Safety Coordinator

Mr. Michael Klisch will act as Golders' sampling and monitoring plan coordinator to make contacts for appropriate scheduling, direct subcontractors in the field, collect environmental quality field samples, and to perform and report on other field operations. Mr. Klisch will also act as Golders' on-site Health & Safety Coordinator for safe and effective actions by Golder field employees. Mr. Klisch confers with the Project Manager and provides information to guide completion of the field tasks and to ensure all activities are conducted in accordance with the Groundwater and Surface Water Sampling and Monitoring Plan.

Health & Safety Officer

The Health and Safety Officer, Ms. Amanda Cote, is responsible for review and implementation of the site Health and Safety Plan (HASP) and communicating the key elements of on-site safety to the field personnel, including; personal protective measures and equipment, emergency preparedness and incident protocol.

Chemist/Validator

The Chemist/Validator, Mr. Tom Stapp reports to the Project Manager. He is responsible for coordinating with the subcontracted laboratories to obtain the required analyses, maintain sample tracking, perform data validation actions and to ensure proper recording of validated data to the database. The Chemist/Validator is responsible for the review and validation of laboratory analysis reports in accordance with guidance documents available from the USEPA. Mr. Stapp directs maintenance of the data files in the project database, and the generation of spreadsheets and report formats of archived data.

Field Sampling Personnel

Golder Field Sampling Personnel will be selected as necessary for completion of Work Plan elements by the Golder Project Manager. The Field Sampling Personnel are responsible for safe conduct while collecting all field samples in accordance with the Groundwater and Surface Water Sampling and Monitoring Plan and QAPP, and performance of other Technical Procedure actions as cited in the Groundwater and Surface Water Sampling and Monitoring Plan. In addition, the Field Sampling Personnel are responsible for accumulation, organization, and maintenance of all information collected during field activities (including sampling logbook, daily activity logbook, chain-of-custody forms, and water-level measurements).

2.2 Use of Subcontractors

SVL Analytical, Inc., located in Kellogg, Idaho has been selected to perform the primary analytical testing and Analytical Resources, Inc., located in Seattle, Washington will perform the primary split sample analysis. Both laboratories hold certifications from the State of Idaho or by reciprocal agreement with other State certifications appropriate to the analytical testing identified in this QAPP. A summary of certifications for each laboratory is as follows:

2.2.1 SVL Analytical, Inc. Certifications

- State of Idaho Department of Health and Welfare, Drinking Water Laboratory Certification for Total Coliform and E. Coli Analytes
- National Environmental Laboratory Accreditation Program (NELAP) Certification through the Florida Laboratory Accreditation Program for:

- Drinking water - primary inorganic contaminants
- Drinking water - secondary inorganic contaminants
- Drinking water - radiochemistry
- Non-potable water - general chemistry
- Non-potable water - metals
- Solid and chemical materials- general chemistry
- Solid and chemical materials - metals

- Adherence to NPDES Testing Standards

2.2.2 Analytical Resources, Inc. Certifications

- National Environmental Laboratory Accreditation Program (NELAP) Certification through the Oregon Laboratory Accreditation Program for drinking water, non-potable water, solids/ chemical wastes, and tissues
- Accredited for analytical methods listed in QAPP Tables under categories of drinking water, non-potable water, or solids/ chemical wastes, by the Washington State Department of Ecology
- Adherence to NPDES Testing Standards

2.2.3 IAS Envirochem Inc. Evaluation

IAS Envirochem Inc. of Pocatello, Idaho is being evaluated as an alternate laboratory for split sample analysis. Copies of their certifications and laboratory QAPP have been requested.

3.0 DATA QUALITY OBJECTIVES

3.1 Appropriate Field Procedures & Analytical Methods

The primary objective of the field activities are to collect representative groundwater, surface water, spring, and non-contact cooling water samples that can be used to characterize groundwater and surface water quality at the Monsanto Soda Springs site and provide information to assess long and short-term water quality changes.

Tables 3-1 through 3-3 list all analytical parameters of interest defined for water sample collection during sampling activities. The complete list of parameters may include metal analyses using USEPA 200.7, or USEPA 200.8 from 'Methods for the Chemical Analysis of Water and Wastes' (USEPA 1983), USEPA 6010 or USEPA 6020 from 'Test Methods for Evaluating Solid Wastes' (USEPA 2007), and various methods for general chemistry parameters found in the aforementioned documents as well as 'Standard Methods for the Examination of Water and Wastes' (APHA 1998). All surface water, groundwater, spring, and non-contact cooling water samples will have standard field parameter list indicators measured including temperature, pH, conductivity, dissolved oxygen, and turbidity.

The objectives for analytical data quality are defined in terms of the quantitation limits achievable using the referenced analytical methods, and in terms of the resulting goals for precision, accuracy, representativeness, completeness, and comparability of analytical data. Quantitation limits are provided for each analytical parameter in Tables 3-1 through 3-3 and are cross-referenced to an applicable standard USEPA reference method. The quality objectives established for long-term monitoring are described as follows:

- Precision: analytical precision shall be reported on field duplicates and matrix spike/ matrix spike duplicate sample data as required by the governing EPA reference methods cited in Tables 3-1 through 3-3. Specific precision criteria for the governing methods as required by data validation guidelines, are presented in the Quality Control Summary tables (Tables 3-4 through 3-6).
- Accuracy (Bias): accuracy shall be reported from certified standard recovery, blank spike recovery, and matrix spike recoveries as required by the governing EPA reference methods cited in Tables 3-1 through 3-3. Specific accuracy criteria for the governing methods as required by data validation guidelines are provided in the Quality Control Summary tables (Tables 3-4 through 3-6).
- Representativeness: Goals for sample representativeness are addressed qualitatively by the sampling locations and intervals defined in the Work Plan. In addition, the use of standard procedures for sample acquisition (as described in Section 4 of this QAPP) will facilitate the collection of representative data.
- Completeness: Completeness is defined as the percentage of valid analytical determinations with respect to the total number of requested determinations in a given sample delivery group; completeness goals are established at 90%. Failure to meet this criterion shall be documented and evaluated in the data validation process described in Section 6 of this QAPP, and corrective action taken as warranted on a case-by-case basis.

- Comparability: Approved analytical procedures shall require the consistent use of the reporting techniques and units specified by the EPA reference methods cited in Tables 3-1 through 3-3 in order to facilitate the comparability of data sets from sequential sampling rounds in terms of their precision and accuracy.

4.0 SAMPLING AND OTHER FIELD PROCEDURES

4.1 Selected Procedures

Technical procedures have been developed to support sampling activities, monitoring actions, data validation, and other technical activities. Reference to technical procedures applicable to individual activities, are provided in Table 4-1, and complete copies for selected technical procedures are provided in Appendix C of the Groundwater and Surface Water Sampling and Monitoring Plan.

Technical Procedures are provided as guidance to technical personnel and as such, require the specific circumstance of application or the knowledge of the field scientist to appropriately apply the guidance criteria. Some technical procedures may have duplicate or similar information provided in other technical procedures that is necessary to be included to provide continuity to the content of the document. Significant changes in the field to technical procedure guidance will be identified and included on a Field Change Request form (TG-1.2-23, “Chain of Custody”).

4.2 Water Sampling

Groundwater, surface water, spring, and non-contact cooling water quality samples will be collected to provide information to characterize groundwater and surface water quality and evaluate water quality trends. Samples will be collected from monitoring wells, Plant production wells, springs, surface water locations along Soda Creek, and non-contact cooling water. Groundwater levels will be measured in monitoring wells. Flows will be measured at surface water sampling locations and from springs.

The Groundwater and Surface Water Sampling and Monitoring Plan and Table 4-1 present technical guidance documents with procedures to collect groundwater and surface water samples and measure groundwater elevations and surface water flows. Substantial changes in the field to established procedures for water quality sampling, groundwater elevation measurement, and flow measurement will be subject to a ‘Field Change Request’ requiring approval from the Golder Project Manager.

4.3 Document Distribution, Variation Request, and Change Control Considerations

The technical procedures and all other procedures cited in this QAPP are subject to the distribution control requirements of QP-5.1, "Document Preparation, Distribution, and Change Control.” Variations from established field procedure requirements may be necessary in response to unique circumstances encountered during sampling activities. All such variations must be documented on a Field Change Request (FCR) form and submitted to the Project Manager for review and approval. A copy of the Field Change Request form is presented in TG-1.2-23 “Chain of Custody”, Exhibit D.

The Project Manager or his assigned Field Sampling Personnel are authorized to implement non-substantive variations based on immediate need, provided that the Project Manager is notified within 24 hours of the variation, and the FCR is forwarded to the Project Manager for review within 2 working days. Substantive variations require notification of the Project Manager, the Work Plan Coordinator, and Potentially Liable Party (PLP) representative prior to implementation, and by forwarding an FCR for review within 2 working days. If the variation is unacceptable to any or all of the reviewers, the activity shall be re-performed or other corrective action taken as indicated in the "Comments" section of the FCR. A copy of the FCR shall be included with all field reports, as well as the data validation report. Changes to the requirements of this QAPP or the Work Plan shall be controlled through the Interim Change Notice (ICN) procedures as discussed in Section 6.5.2 of QP-5.1.

4.4 Sample Quantities, Types, Locations, and Intervals

Sample quantities, types, locations, and intervals for the groundwater shall be as specified in the Groundwater and Surface Water Sampling and Monitoring Plan. Field quality control samples shall be included in the minimum quantities specified in Section 7 of this QAPP. Appropriate documentation of the purpose of the sample shall be maintained in the field log, and identified by the assigned sample number; copies of sample identification records shall be separately provided to the data validator. See Section 6 of this QAPP.

4.5 Sample Identification and Labeling Requirements

Sample labels will be attached to each sample container with an assigned field sample identification number applied as each sample is collected during the field activities. The number system will appear on each sample bottle or container collected and will identify a unique sample ID number applied to one collection sequence for one sample, regardless of the number of bottles and containers collected. The number system will ensure field QC samples will remain indistinguishable from the field locations. The label will contain the sampler's initials, one collection date, and one collection time appropriate for each sample, and will be cross referenced by the sample number to identify the location, depth, or monitoring well number with geological data in the field notes. An example label is provided as follows:

Golder Associates

Sample Number:__________________

Preservative:______________________

Analysis:________________________

Sample Date: __/ / Time: ______

Sampler: ________________________

Each sample bottle label will also identify the laboratory analysis to be performed, noting the identified method number as stated in Tables 3-1 and 3-2 and the preservative added for the appropriate analytical parameter as indicated on the bottle label. Identification numbers shall be recorded on the field report logs and sample integrity data sheets with the applicable sampling procedures, and on the chain of custody/sample analysis request form supplied to the analytical laboratory.

4.6 Sample Container Type, Volume, Preservation, and Handling Requirements

All sample containers, container preparation, preservatives, trip blank (as necessary), and sample storage chests shall be provided by the analytical laboratory as part of their agreement for services. Sample container type, volume requirements, preservation requirements, and special handling requirements are listed by analytical category in Table 4-2 for all water matrices.

All samples shall be sealed, labeled, properly identified, and submitted to the analytical laboratory under formal chain of custody requirements as described in Section 4.7 of this QAPP. Transport sample chests will be secured with a custody seal on the outside, with signature and date provided by the attending field scientist.

4.7 Chain of Custody Considerations

All samples obtained during the course of this investigation shall be controlled as required by procedure TG-1.2-23, "Chain of Custody." Chain of custody forms (see Exhibit C in TG-1.2-23) shall be completed for each shipment of samples as described in the procedure. Chain of Custody forms shall specifically identify the applicable reference methods specified in Tables 3-1 and 3-2 as appropriate for each individual sample. Sample Integrity Data Sheets (see Exhibit B in TG-1.2-23) shall be completed for all sample collection locations, and cross reference the location and sample depth with the sample identification entered on the Chain of Custody. All laboratory chain of custody and sample tracking procedures shall ensure traceability of analytical results to the original samples through the analytical method referenced on the chain of custody, and the laboratory applied tracking number, which is traceable to unique sample identification numbers as specified in Section 4.5 above.

4.8 Sampling Equipment Decontamination

Most monitoring wells at the Monsanto project site have dedicated sampling apparatus to collect representative samples unique to the aquifer zone and depth for the well being sampled. Other locations not suited to a dedicated system will be sampled using appropriately decontaminated equipment. All non-dedicated sampling equipment (in contact with sample) shall be thoroughly cleaned prior to each sampling event to prevent cross-contamination between samples and to ensure accurate representation of analytes of interest in each sample interval. Personnel performing decontamination shall wear rubber gloves, face or eye shields, and such other safety equipment as directed by the project-specific HASP. A summary of steps used to attain proper decontamination follows:

- Samplers and sampling tools shall be disassembled as necessary and placed in clean, dedicated buckets during and after decontamination procedures to collect wash and rinse fluids.
- For samples requiring inorganic analyses, non-dedicated equipment shall be cleaned with a brush and non-phosphate detergent - water mixture such that all visible solid matter is removed.
- Steam cleaning may be conducted on drilling augers or down-hole soil sampling equipment in place of hand washing.
- A second wash is performed on non-dedicated equipment after the detergent/ water wash.
- A second and final rinse of distilled/deionized water is then applied and the sampler is ready for use.
- If the sampler will not be used immediately, it should be stored for short term in a clean plastic bag or container to protect against ambient air contaminants.

If the non-dedicated equipment retains visible matter that is not amenable to cleaning after the previously stated actions, the equipment will be retired from the sampling procedures and not used again. Samplers shall be reassembled using clean rubber gloves. All wash and rinse fluids shall be transferred to purge water collection devices, and sent for disposal to the purge water collection pond reserved for that purpose.

4.9 Calibration Requirements

Calibration of all measuring and test equipment, whether in existing inventory or purchased for this investigation, shall be controlled as required by procedure QP-11.1, "Calibration and Maintenance of Measuring and Test Equipment." Lease equipment shall require certifications or other documentation demonstrating acceptable calibration status for the entire period of use for this project. Field calibration requirements shall be in compliance with the technical procedure describing the instrument's use and/or with the manufacturer's instructions issued with the equipment. Method and analytical equipment-specific calibration requirements applicable within the individual analytical laboratories are addressed by the individual laboratory QA plans.

5.0 ANALYTICAL PROCEDURES

Tables 3-1 and 3-2 cross-reference the analytes of interest of this investigation to the standard reference methods, practical quantitation limits (PQLs), quality control guidelines, and sample handling procedures that shall be established as contractual requirements between Golder and the subcontracted analytical laboratory. The subcontracted laboratory is responsible for implementing the analytical methods selected, documenting through Standard Operating Procedures (SOP) modifications (if any) to the methods, and providing these documents for review upon request. Any changes to the method number selected for analysis and identified in Tables 3-1 through 3-3 must first be brought to the attention of the Golder Project Manager in writing before analysis can commence.

The contractual requirements for PQLs and the most appropriate analytical methods are based upon historical records established for the site and requirements for satisfying cleanup standard guidelines as stated in National Recommended Water Quality Criteria (USEPA 2011), and the Idaho primary and secondary groundwater quality standards as presented in the Idaho Department Administrative Policy Act (IDAPA) 58, Title 01, Chapter 11; Groundwater Quality Rule, (IDAPA 2011a) and surface water quality standards presented in IDAPA 58, Title 01, Chapter 02 (IDAPA 2011b). Where necessary, the laboratory will select the most appropriate method required to meet the cleanup standard.

6.0 DATA REDUCTION, VALIDATION, AND REPORTING

6.1 Minimum Requirements for Laboratory Analytical Data Packages

All analytical data packages submitted by the analytical laboratory shall include the following:

- Sample receipt “condition found” record, noting dates of sample receipt; chain-of-custody and shipping documentation including identification of field sampling personnel, and shipping personnel (or organization); copies of completed chain of custody documentation;
- Analytical hard copy (paper) summary results for each sample containing neat or dilution adjusted results for all analytes/constituents requested in the chain of custody, request for analysis or purchase order;
- Analytical quality control results and summary documents for initial and continuing calibration standards, laboratory method blanks, duplicates, laboratory control samples, blank spike/blank spike duplicates, matrix spike/matrix spike duplicates, method of standard additions, serial dilutions, surrogates and internal standards;
- Sample extraction and preparation summary data including dates of sample extraction and analysis and analytical sequence information for each sample set, and each sample dilution and reanalysis, and
- Electronic data diskettes or electronic deliverables that provide the summarized results, date of extraction and analysis, quality control data results and true values, client and laboratory sample identifications, analysis methods, dilutions applied and appropriate detection or reporting limits.

All data packages for all analytical parameters shall be reviewed and approved by the analytical laboratory's QA Officer prior to submittal for validation.

6.2 General Validation Requirements

All analytical data packages from each sample delivery group shall be validated by the detailed review and calculation over-check processes described in “USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review” (USEPA 2010). Data validation guidance will be augmented in part by “Guidance on Environmental Data Verification and Data Validation; USEPA QA/G-8” (USEPA 2002b). Data validation work will be performed in order to ensure that the laboratory has met all contractual requirements, all applicable reference method requirements, and has met the data quality objectives discussed previously in Section 3 and Tables 3-4 through 3-6. . Validated data will be stored as indicated in procedure TP-2.2-12, "Analytical Data Management" for each sample delivery group. A sample delivery group may be interpreted as a group of twenty samples, or the group of samples delivered to the laboratory in a single week, whichever occurs first.

The data validator shall document all contacts made with the laboratory to resolve questions related to the data package. The data validator shall prepare a technical report applicable for the specified method, documenting the evaluation of laboratory blanks, field blanks, equipment blanks, duplicates, matrix spikes/matrix spike duplicates, laboratory control samples, calibration data, and any re-qualification of analytical results required as a result of the validation exercise. The validation report, laboratory contact documentation, copies of the laboratory sample summary reports, and the as-reviewed laboratory data package shall be routed to the Project Manager for data assessment purposes and to the permanent project records.

7.0 QUALITY CONTROL PROCEDURES

7.1 Field Generated Quality Control Samples

All analytical samples shall be subject to quality control (QC) measures in both the field and laboratory. The following minimum field quality control requirements apply to all analyses. These requirements are adapted from "Test Methods for Evaluating Solid Waste" (SW-846) (USEPA 2007).

- ***Field duplicate samples.*** An effort will be made to obtain sufficient sample quantities for the purpose of collecting field duplicates. Field duplicates will be collected of surface and groundwater samples that are suspected, based upon field observations, to contain contaminants, and where volume requirements are sufficient. Duplicate samples shall be collected from the same sampling location using the same equipment and sampling technique, and shall be placed into identically prepared and preserved containers. Therefore, duplicate samples will be generated for water collected from groundwater wells and surface water locations at the frequency noted in Tables 3-4 and 3-5 of at least one duplicate sample for every 20 samples. All field duplicates shall be identified with a unique sample ID number and will be analyzed independently (blind) as an indication of gross errors in sampling techniques.
- ***Split Laboratory samples.*** Split samples are identical samples collected at the same time in the same way, contained and transported in the same manner, but are sent to an alternate laboratory. Split samples are used as a performance audit of the primary laboratory. At a minimum, at least one split sample for every 20 samples,, or one split shall be collected per sampling event, whichever is greater. Split sampling shall be distributed evenly throughout each sampling period, with representative samples suspected to contain contaminants and where volume requirements are sufficient.
- ***Equipment blanks.*** Equipment blanks shall consist of pure deionized/ distilled commercially available water washed through decontaminated non-dedicated sampling equipment and placed in containers identical to those used for actual field samples. Equipment blanks verify the adequacy of sample containers, non-dedicated sampling equipment decontamination procedures, and the proficiency of the field technician to eliminate fugitive contaminants. Therefore, equipment blanks will be generated for water collected from groundwater wells and surface water locations at the frequency noted in Tables 3-4 and 3-5. The equipment blanks shall be collected at a location based upon the potential for the presence of field contaminants.
- ***Trip blanks.*** Trip blanks will not be required of the participating laboratory, unless and until contaminants are found in batch equipment blanks with interfering quantities of analytes that cannot be explained by sampling error, or by laboratory error. If required, they shall be created and tested by the laboratory prior to shipment, accompanied with the environmental sample set, and then returned unopened to the laboratory. The use of trip blanks will be at the Project Manager's direction, and are prepared as a check on possible contamination originating from container preparation methods, shipment, handling, storage, or site conditions.

7.2 Laboratory Quality Control Samples

The internal quality control checks performed by the analytical laboratory shall meet the following minimum requirements:

- ***Matrix spike and matrix spike duplicate samples.*** Matrix spike and matrix spike duplicate samples require the addition of a known quantity of a representative analyte of interest to the sample as a measure of recovery percentage. The spike shall be made in a replicate of a field sample or field duplicate sample. Replicate samples are separate aliquots removed from the same sample container in the laboratory. Spike compound selection, quantities, and concentrations shall be described in the laboratories analytical procedures as appropriate to the analytical method. One sample shall be spiked per analytical batch, or once every 20 samples, whichever is greater.
- ***Quality control reference samples (check samples).*** A quality control reference sample shall be prepared from an independent standard at a concentration other than that used for calibration, but within the calibration range. The quality control reference sample is analyzed after the initial calibration and before any samples are analyzed, and shall be run with every analytical batch, or every 20 samples, whichever is greater. Reference samples are required as an independent check on analytical technique and methodology.
- ***Method blanks.*** Method blanks are prepared during the preparation of samples in the laboratory to determine the proficiency of the laboratory at eliminating fugitive vapors, reagent contaminants, and preparation vessel carryover contaminants. The method blank shall be prepared using the same procedure used for preparation of the samples, at the same time, and involving the same reagents. The method blank must be tested after the quality control reference sample and before any samples are analyzed, and shall be run with every analytical batch or 20 samples, whichever is more frequent.

8.0 DATA ASSESSMENT PROCEDURES

As previously discussed in Section 6, analytical data shall first be compiled by the analytical laboratory, and reduced to include the specified deliverable elements. The data will be validated by project personnel in compliance with existing validation guidelines and then reported to the Project Manager and to the Client. Data assessment will be performed on the distributions and statistical characteristics of the validated data, and will consist primarily of comparisons of the data to applicable regulatory levels and historical data to assist in site characterization.

9.0 DATA MANAGEMENT

Data management involves the routing and storage of all incoming data and correspondences unique to the project activities for the purpose of security, ease of access, and compliance with project goals. The following sections describe standards in place to complete the data management process.

9.1 Records Management

All records generated for project work, will be filed and maintained in access controlled project archives as required by procedure QP-16.1 “Quality Assurance Records Management”. Records are defined as completed and signed documents that provide evidence of a service or a communication relevant to the project. Records produced during the course of the Monsanto Soda Springs project may include, but not be limited to:

- Incoming and outgoing correspondence and facsimile transmissions
- Analytical data packages and analytical quotes
- Project contracts, agreements, and amendments
- Purchase orders and subcontractor agreements, quotes and receipts
- Historical file copies of the data and communiqué provided by the Monsanto Soda Springs site and representatives
- The Work Plan, Quality Assurance Project Plan, and Health and Safety Plan
- Technical field logs and field reports
- Interim change reports, procedure alteration checklists, surveillance inspection reports, and non-conformance/ incidence reports
- Computer disk files, electronic copies of analytical data, and relevant E-mail communications

9.2 Analytical Data Management

Laboratory data will be provided to Golder in both hard copy (paper) and electronic format. The paper copy will be routed to the data validator for confirmation of analytical data receipt and subsequent validation activities. Electronic data, by diskette, or by electronic (E-mail) delivery will be reserved by the data management specialist. The electronic data will include completed report copy versions in ‘pdf’ or facsimile form, and in spreadsheet form amenable to inclusion by electronic import to a database. Validated analytical data packages and diskettes will be routed to the project records for controlled storage and the validated data shall be processed into the analytical database in accordance with guidance found in Technical Procedure TP-2.2-12 “Analytical Data Management”.

9.3 Data Review and Reporting

Following receipt and final data validation of groundwater analytical results, concentrations of detected analytes will be compared to established action levels. The proposed action levels for water quality at the project site are provided in Tables 3-1 and 3-2 when compared to surface water criteria (USEPA 2011, IDAPA 2011b) or groundwater criteria (IDAPA 2011a).

Once data has been received, validated and reviewed it will be included into a summary report. The report will include the date of the sampling event, a discussion of groundwater and surface water findings, a tabular presentation of water analytical results, and comparison to established action levels for the site.

9.4 Records Turnover

Records turnovers shall be in accordance with the Quality Procedure QP-16.1 and shall be inspected prior to transmittal by the Golder Project Manager or his designee.

10.0 REFERENCES

APHA. 1998. *Standard Methods for the Examination of Water and Wastewater*, 20th Edition, American Public Health Association.

Golder Associates Inc., (Golder). 1995. *Phase II Remedial Investigation Report for the Soda Springs Elemental Phosphorus Plant*, prepared for Monsanto Chemical Company by Golder Associates, Inc., Redmond, Washington, November 21.

Golder. 2012. Groundwater and Surface Water Sampling and Monitoring Plan, June.

Idaho Administrative Policy Act (IDAPA). 2011a. *Water Quality Standards*, IDAPA 58, Title 01, Chapter 02.

IDAPA. 2011b. *Ground Water Quality Rule,* IDAPA 58, Title 01, Chapter 11.

United States Environmental Protection Agency (USEPA). 1983. *Methods for Chemical Analysis of Water and Wastes* (EPA-600/ 4-79-02), March.

USEPA. 2002a. *USEPA Guidance for Quality Assurance Project Plans, USEPA QA/G-5,* (EPA/240/R-02/009), December.

USEPA. 2002b. Guidance on Environmental Data Verification and *Data Validation; EPA QA/G-8,* EPA/240/R-02/004, November.

USEPA. 2007. *Test Methods for Evaluating Solid Waste, Revision 6, (SW-846), February*.

USEPA. 2010. USEPA Contract Laboratory Program, *National Functional Guidelines for Inorganic Data Review,* Final, EPA-540/R-00-006, January.

USEPA. 2011. National Recommended Water Quality Criteria, http://water.epa.gov/scitech/swguidance/standards/current/index.cfm (accessed April 19, 2011).

TABLES

Table 3-1: Sample Collection / Metal Analytes

		Idaho Groundwater Quality Standards[a]	National Surface Water Quality Criteria[b]	Idaho Surface Water Criteria[c]	Method Reference and Reporting Limits (RL)				Method Quality Control	
Parameter	CAS Number	Units (µg/L)	Units (µg/L)	Units (µg/L)	ICP-AES[d]	RL Units (µg/L)	ICP-MS[e]	RL Units (µg/L)	Precision RPD	Accuracy % Recov.
Cadmium	7440-43-9	5	0.25	0.6	6010C	5	6020A	1	<20%	75-125%
Calcium	7440-70-2	NA	NA	NA	6010C	5000		--	<20%	75-125%
Magnesium	7439-95-4	NA	NA	NA	6010C	5000		--	<20%	75-125%
Manganese	7439-96-5	50[II]	NA	NA	6010C	10	6020A	1	<20%	75-125%
Molybdenum	7439-98-7	NA	NA	NA	6010C	8		--	<20%	75-125%
Potassium	7440-09-7	NA	NA	NA	6010C	5000		--	<20%	75-125%
Selenium	7782-49-2	50	5	5	6010C / SM 3114C	200	6020A	3	<20%	75-125%
Sodium	7440-23-5	NA	NA	NA	6010C	5000		--	<20%	75-125%
Vanadium	7440-62-2	NA	NA	NA	6010C	30	6020A	1	<20%	75-125%
Zinc	7440-66-6	5000[II]	120	120	6010C	60	6020A	2	<20%	75-125%

Notes:

NA Not available for this analyte.

a - Idaho Primary Constituent Groundwater Quality Standards unless indicated as Secondary Constituent Groundwater Quality Standard (Superscript 'II' designation identifies an Idaho Secondary Constituent Groundwater Quality Standard per IDAPA 58.01.11, 2011).

b - National Recommended Water Quality Criteria: 2011; Values are for freshwater chronic criteria concentrations using a hardness coefficient of 100 mg/L where applicable (Shaded value is currently below Method Reporting Limits for the method cited).

c.- IDAPA 58 Title 01, Chapter 02 Water Quality Standards, chronic criteria

d - ICP-AES; Ion coupled plasma and atomic emission spectroscopy (except Se). Reference from 'Methods for Chemical Analysis of Water and Wastes'
(EPA-600/ 4-79-02).

e - ICP-MS; Ion coupled plasma and mass spectrometry.

Table 3-2: Sample Collection / General Chemistry Analytes

Parameter	Idaho Groundwater Quality Standards[a]	National Surface Water Quality Criteria[b]	Idaho Surface Water Quality Criteria[c]	Method Reference[d]	Detection Reporting Limit	Precision RPD[e]	Accuracy % Recovery
Total Alkalinity (as $CaCO_3$)	NA	20 mg/L	- -	SM 2320B	1 mg/l	<20%	75-125%
Ammonia/ Ammonium (as N)	NA	pH, Temp. dependent	pH, Temp. dependent	EPA 350.1	0.01 mg/l	<20%	75-125%
Chloride	250 mg/L[II]	230 mg/L	- -	EPA 300.0	1 mg/l	<20%	75-125%
Fluoride	4 mg/L	- -	- -	EPA 300.0	1 mg/l	<20%	75-125%
Nitrate/Nitrite (as N)	10 mg/L	- -	- -	EPA 353.2	0.05 mg/l	<20%	75-125%
Total Phosphorus (as P)	NA	- -	- -	EPA 365.2	0.01 mg/l	<20%	75-125%
Sulfate	250 mg/L[II]	- -	- -	EPA 300.0	1 mg/l	<20%	75-125%
TDS	500 mg/L[II]	- -	- -	SM 2540 C	10 mg/l	<20%	NA

Notes:

a – Idaho Primary Constituent Groundwater Quality Standards unless indicated as Secondary Constituent Groundwater Quality Standard by superscript II.

b - National Recommended Water Quality Criteria: 2002; Values are for freshwater chronic criteria concentrations using a hardness coefficient of 100 mg/L where applicable.

c - IDAPA 58 Title 01, Chapter 02, Water Quality Standards, chronic criteria.

d – Methods for Chemical Analysis of Water and Wastes, (EPA 1983); Standard Methods for Examination of Water and Wastewater, (APHA 1998).

e – Relative Percent Difference.

Table 3-3: Water Field Parameter Monitoring List

Field Tests	Method[a]	Target Water PQL[b]	Typical Instrument Applied[c]
Temperature	SM2550	0.1 deg. C	Golder Calibrated Mercury Thermometer
pH	EPA 150.1	0.05 units	Orion 3 Star with pH Electrode or Model 250Aplus with Combination Glass Electrode.
Specific Conductance	EPA 120.1	5 umhos/cm	Orion 3 Star with Conductivity Electrode Cell or Model 115Aplus with Epoxy 2 Electrode Conductivity Cell.
Turbidity	EPA 180.1	1 NTU	Hach 2100P with dual optical compensation.
Dissolved Oxygen	SM4500-O	0.1 mg/L	Orion 3 Star with Dissolved Oxygen Electrode or Model 810Aplus with Combination Glass Electrode.
Oxidation-Reduction Potential	ASTM D1498-00	0.1 mV	Orion 3 Star with Eh Electrode or Model 250A plus with Eh Electrode.

Notes:

a - Methods cited are from 'Methods for the Chemical Analysis of Water and Wastes' (EPA-600/4-79-20; EPA 1983); and 'Standard Methods for the Examination of Water & Wastewater' (1998, 20th Ed.).

b - PQL: Practical Quantitation Limits established by Manufacturers recommendation.

c - Orion and Hach are registered trademarks. Refer to instrument operator manuals for calibration and troubleshooting.

Table 3-4: Quality Control Summary; Metal Analyses

Parameter	Description
Method Reference	Methods for Chemical Analysis of Water and Wastes, (EPA 1983); Test Methods for Evaluating Solid Waste; SW-846, (EPA 2007) Standard Methods for Examination of Water and Wastewater, (APHA 1998)
Matrix	Surface water, Groundwater.
Analytes	Metals lists as indicated in Table 3-1.
Holding Time	6 Months.
Laboratory Instrument Calibration	ICP: A blank and at least one calibration standard. The low level standards must be analyzed at the method specified concentration at the required frequency.
Laboratory Method Blank	Blank sample is analyzed at each analyte parameter and no analytes should be found in the blank. At least one preparation blank must be prepared for each matrix per 20 field samples or each batch whichever is more frequent. If any analyte concentration in the preparation blank is above the reporting limit, the lowest concentration of that analyte in the associated sample must be 10 times the concentration in the blank.
Laboratory Calibration	Laboratory calibration blanks analyzed at beginning and end of analytical batch and after initial and continuing calibration or every 10 samples or two hours, whichever is more frequent.
Equipment Blanks	GROUNDWATER: Equipment blanks will be collected at a minimum frequency of one per each set of twenty samples collected, for each type of collection device used. SURFACE WATER: Equipment blanks will be collected at a minimum frequency of one per each set of twenty samples collected.
Laboratory QC Check Standards	ICP initial calibration verified with independent standard %R 90-110. Digest an independent LCS with each sample batch for ICP if available %R 80-120.
Duplicate Sample	GROUNDWATER: Field duplicates are scheduled to be collected at a minimum frequency of one per each set of twenty samples collected. Each is prepared as a blind field duplicate. Relative percent differences (RPD) between field duplicates are advisory only; ≤20% for water samples. (MS/MSD or BS/BSD checked for RPD also). SURFACE WATER: Field duplicates will be collected at a minimum frequency of one per each set of twenty samples collected. Additional criteria as above.
Laboratory Matrix Spike/ Matrix Spike Duplicate Sample	Analyze spiked field sample at frequency of one per twenty samples or each batch, whichever is more frequent for groundwater and surface water samples. Percent recovery (%R) between 80-120%. Use method of standard additions for Se by hydride generation if interference is indicated.
Sample Collection	WATER: 1,000 ml polyethylene bottle acidified with HN03 to pH <2 and cool to 4°C.
Other Laboratory QC Criteria	ICP: Analyze ICS at beginning and at end of run or twice during 8 hour shift, whichever is more frequent. Results ±20% of true value. To verify linearity near the detection limit, analyze standard at 2X the limit and analyze at the beginning and end of the run or twice per 8 hours. Serial dilution analysis performed if concentration is 50X limit, must agree ±10% of the original value. All measurements minimum of 2 replicate exposures, report average. Se by hydride generation: Serial dilution analysis performed if concentration is 25X limit, must agree ±10% of the original value. Method of standard additions required if interference is indicated.

Table 3-5: Quality Control Summary; General Chemistry Analyses

Parameter	Metals
Method Reference	Chemical Methods for the Analysis of Water and Waste. Standard Methods for the Examination of Water and Wastes.
Matrix	Groundwater, Surface water.
Analytes	Total Alkalinity (as $CaCO_3$), Ammonia and Ammonium (as N), Chloride, Fluoride, Sulfate, Nitrate+nitrite-N, Total Phosphorus (as P), TDS.
Holding Time	28 days for chloride, fluoride, sulfate, unpreserved. 28 days for ammonia, nitrate/nitrite, phosphorus if preserved. 14 days for alkalinity unpreserved, and 7 days for TDS, unpreserved.
Calibration	A blank and at least three calibration standards for spectrophotometer, and anion analysis. One standard must be analyzed at or near the method reporting limit. Verify calibration prior to sample analysis, every twenty samples and at the conclusion of sample analysis. Balance check with NIST traceable standard weight for TDS analysis.
Method Blank	Blank sample is analyzed at each analyte parameter and no analytes should be found in the blank. At least one preparation blank must be prepared for each matrix per 20 field samples or each batch whichever is more frequent. If any analyte concentration in the preparation blank is above the reporting limit, the lowest concentration of that analyte in the associated sample must be 10 times the concentration in the blank.
Other Blanks	Analyze calibration blank at beginning and end of analytical batch and after initial and continuing calibration or every 10 samples or two hours, whichever is more frequent. Evaluate other associated blanks such as equipment blanks and field blanks at the same frequency of method blank analyses above.
QC Check Standards	Initial calibration verified with independent standard %R 90-110, with the exception of TDS. Digest an independent LCS with each sample batch for each matrix if available, acceptable %Recovery 80-120.
Duplicate Sample	Analyze one duplicate per 20 field samples or each batch for each matrix. Relative percent difference (RPD) ≤20% for water samples ≤35% for soil samples. Blind field duplicate sample recommended.
Spike Sample	Analyze spike field sample at frequency of one per twenty samples or each batch, whichever is more frequent for each matrix. Percent recovery (%R) between 80-120%.
Sample Collection	Water for Nitrite/Nitrate, Ammonia, & Phosphorus analysis; 1000 ml, preserve with H2SO4 to pH < 2, refrigerate at 4°C. Water for Chloride, Fluoride, Sulfate, Alkalinity analysis; 1000 ml polyethylene bottle unpreserved, refrigerate at 4°C.
Other QC Criteria	Analyze ICS at beginning and at end of run or twice during 8 hour shift, whichever is more frequent. Results ±20% of true value. To verify linearity near the detection limit, analyze standard at 2X the limit and analyze at the beginning and end of the run or twice per 8 hours. Verify linear ranges quarterly. Results must be within ±5% of true value. All measurements minimum of 2 replicate exposures, report average.

Table 3-6: Quality Control Summary; Field Parameters

Parameter	Description
Method References	GAI Technical Procedures TG-1.2-20, Collection of Groundwater Quality Samples; TP-1.2-26 Surface Water Sampling Methods. Orion and Hach Technical Operator Manuals
Matrix	Surface Water (Streams) and Groundwater (well sampling).
Analytes	pH, specific conductivity, dissolved oxygen, turbidity, redox potential, and temperature.
Maximum Holding Time	Record all field parameters immediately upon collection or during steady state conditions.
Calibration	At least two reference buffers or standards at a high and low concentration are used to calibrate pH, conductivity. A blank and at least one calibration standard shall be used for turbidity, and dissolved oxygen slope determined by saturated atmosphere. Verify calibration prior to sample analysis and at the conclusion of sample analysis. NIST traceable thermometer shall be used for temperature measurements, no field calibration is required.
Method Blank	A method blank or rinse blank sample is analyzed when required to check calibration.
Equipment Blanks	Equipment blanks will include monitoring of distilled or deionized water used in equipment preparation as appropriate.
QC Check Standards	Reanalysis of standards following field sample analyses is required. Verification of standards values should be ±10%.
Surrogate	NA
Internal Standard	NA
Duplicate Sample	Duplicate sample analyses are not required, however, repeat analysis of a second sample aliquot is recommended for all parameters and required for groundwater sampling to verify stability of field measurements within 10% for all parameters (0.5 °C for temperature).
Spike Sample	Spike sample analyses are not required.
Sample Collection	Minimize both atmospheric contact and delay on analyses of all field parameters. A closed cell sampling configuration may be used.
Other QC Criteria	The working calibration must be verified before and after field sampling analyses. If the response for any analyte varies from the expected value by more than ±10% (0.5 °C for temperature), the test must be repeated using fresh calibration standards.

Table 4-1: Golder Technical Procedures and Quality Control Documents

TG-1.2-20	Collection of Groundwater Quality Samples
TG-1.2-23	Chain of Custody
TP-1.2-26	Surface Water Sampling Methods
TP-1.2-27	Measurement of Stream Discharge Using a Current Meter
TG-1.4-6a	Manual Groundwater Level Measurement
TP-2.2-12	Analytical Data Management
QP-5.1	Document Preparation, Distribution, and Change Control
QP-10.1	Surveillance Inspection
QP-11.1	Calibration and Maintenance of Measuring and Test Equipment
QP-14.1	Corrective and Preventive Action
QP-16.1	Quality Assurance Records Management

Table 4-2: Sample Container Types, Volumes, Handling, Preservation, and Holding Times

Analytes	Analytical Method	Container Type	Special Handling	Preservation	Maximum Holding Time
pH, Temperature, Conductivity, Dissolved Oxygen, Turbidity	See Table 3-3	Field Parameters; Sample is not collected	See Table 3-6	Field Parameters; Sample is not collected	Field Parameters; Sample is not collected
Dissolved Metals, Selenium	EPA 6010B / 6020 SM 3114C	1, 1000 mL polyethylene bottle.	Use 0.45 um filter only for samples with turbidity >5 NTU (Bailer collected samples only). Collect into preserved bottle, fill to neck	HNO_3, pH < 2, store at 4°C.	6 months 6 months
Total Metals, Selenium	EPA 6010B/ 6020 SM 3114C	1, 1000 mL polyethylene bottle.	Fill to neck	HNO_3, pH < 2, store at 4°C	6 months 6 months
Total Alkalinity	EPA 310.1	1, 1000 mL narrow mouth polyethylene bottle.	Fill to neck, do not uncap until ready for analysis	None, store at 4°C	14 days
Total Phosphorus, Ammonia and Ammonium, Nitrate+Nitrite-N	EPA 365.2 EPA 350.1 EPA 353.2	1, 1000 mL narrow mouth polyethylene bottle.	Fill to neck	H_2SO_4, pH <2, store at at 4°C.	28 days
Chloride, Fluoride, Sulfate	EPA 300.0	1, 1000 mL polyethylene bottle.	Fill to neck	None, store at 4°C	28 days
Total Dissolved Solids	EPA 160.1	1, 1000 mL polyethylene bottle.	Fill to neck	None, store at 4°C	7 days

APPENDIX D
QUALITY ASSURANCE PROJECT PLAN FOR SOIL AND SOURCE MATERIAL SAMPLING, UBZ-2 SOURCE AREA CHARACTERIZATION

REPORT

DRAFT

QUALITY ASSURANCE PROJECT PLAN FOR SOIL AND SOURCE MATERIAL SAMPLING UBZ-2 SOURCE AREA CHARACTERIZATION

Monsanto Soda Springs Facility, Soda Springs, Idaho

Submitted To: Monsanto Soda Springs Plant
Highway 34
Soda Springs, ID 83276

Submitted By: Golder Associates Inc.
18300 NE Union Hill Road, Suite 200
Redmond, WA 98052 USA

Distribution:

3	Copies	Monsanto, Soda Springs, Idaho
1	Copy	EPA Region X, Seattle, Washington
1	Copy	IDEQ-Pocatello, Idaho
1	Copy	CH2M-Hill, Boise, Idaho
2	Copies	Golder Associates Inc., Redmond, Washington

July 24, 2013 **Project No. 913-1101-002-002.2G**

A world of capabilities delivered locally

Golder Associates

Table of Contents

List of Tables

1.0 PROJECT DESCRIPTION

1.1 Project Objective and Historical Background

This Quality Assurance Project Plan (QAPP) is to support specific procedures, analytical methods, and other detailed instructions that will be performed in conjunction with the Work Plan for Upper Basalt Zone 2 (UBZ-2) Phase 2 - Source Area Field Investigations at the Monsanto Elemental Phosphorus Plant in Soda Springs, Idaho (Plant). This plan supports the third Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) five-year review for the Plant. The QAPP was prepared in significant accordance with the United States Environmental Protection Agency (USEPA) guidance for quality assurance project plans (USEPA 2002a) and provides procedures for collection of representative samples, making accurate measurements, and obtaining representative, accurate, and precise analytical data. Work Plan tasks include excavating test pits and collection of soil and potential source area materials from the test pits, drilling of boreholes and collection of soil, potential source, and vadose zone materials from borehole cuttings, and installation of monitoring wells and collection of groundwater quality, groundwater elevation, and hydraulic conductivity data. This QAPP specifically supports collection, analysis, and quality control/quality assurance for soils, potential source material, and vadose zone solids sampling and analysis.

1.2 Site Description

A discussion of the Plant area, source area history and characterization, and groundwater conditions are provided in the Work Plan (Golder 2013).

1.3 Sampling Program Design

A detailed description of investigation approach is provided in Section 3 of the Work Plan. The overall intent of the Work Plan is to characterize former source areas through subsurface investigations including:

- Test pits to characterize shallow soil and fill, potential source materials, and vadose zone materials and collect samples for geochemical analysis in UBZ-2 in an area designated as a “Tailings Pond” on historic maps.
- Boreholes to characterize soil, potential source materials and vadose zone materials below potential source areas and collect samples for geochemical analysis in UBZ-1, UBZ-2, and UBZ-4.

The locations to be investigated at the site are described in the text and illustrated on figures of the Work Plan, and are summarized in Table 1-1.

2.0 PROJECT ORGANIZATION

2.1 Organizational Structure

Project directors and their contact information are provided in the table below. The organizational structure for field activities for the Monsanto Soda Springs site is provided in the following table.

Role	Name/ Email Address	Company/ Address	Phone
EPA Regional Project Manager	Mark Ader Ader.Mark@epa.gov	EPA Region 10 Environmental Cleanup Office (ECL-115) U.S. EPA Region 10 1200 6th Ave. Seattle, WA 98101	206 553-1849
EPA Regional Quality Assurance Manager	Gina Grepo-Grove Grepo-Grove.Gina@epa.gov	EPA Region 10 Regional Quality Assurance Office U.S. EPA Region 10 1200 6th Ave. Seattle, WA 98101	206-553-1632
IDEQ Project Manager	Clyde Cody clyde.cody@deq.idaho.gov	IDEQ 1410 N. Hilton Boise, Idaho 83706	208-373-0556
Monsanto Project Manager	Jim McCulloch james.r.mcculloch@monsanto.com	Monsanto Chemical Company Soda Springs Plant Highway 34 Soda Springs, ID 83276	(208) 547-1233
Golder Project Manager	David Banton	Golder Associates Inc. 18300 Union Hill Rd. Ste 200 Redmond, WA 98052	425-883-0777 (425) 503-9331 cell
Golder Task Manager/Quality Assurance Manager/Health and Safety Leader	Michael Klisch	Golder Associates Inc. 18300 Union Hill Rd. Ste 200 Redmond, WA 98052	425-883-0777 206-713-5878 cell
Field Sampling Team	TBD	Golder Associates Inc. 18300 Union Hill Rd. Ste 200 Redmond, WA 98052	425-883-0777
Data Management	Alyssa Neir	Golder Associates Inc. 18300 Union Hill Rd. Ste 200 Redmond, WA 98052	425-883-0777
Data Validation	Tom Stapp	Golder Associates Inc. 18300 Union Hill Rd. Ste 200 Redmond, WA 98052	425-883-0777
Laboratory	SVL Analytical Chris Meyer	One Government Gulch Kellogg ID 83837	208-784-1258 800-597-7144
Split Laboratory	Analytical Resources Inc. Mark Harris	4611 S. 134th Place Suite 100 Tukwila, WA 98168-3240	206-695-6201

Monsanto Project Coordinator

The Monsanto project coordinator, Mr. Jim McCulloch, is responsible for review of work plans for environmental sampling activities on Monsanto's behalf, on-site coordination of the sampling and analysis events, and providing access as needed to Monsanto facilities and equipment to facilitate sample collection activities.

Golder Project Manager & Quality Assurance Coordinator

The Project Manager, Mr. David Banton, is responsible for planning and executing all environmental sampling and analysis and for preparation of analytical data reports, and all associated Technical memoranda including submittals to the Idaho Department of Environmental Quality (IDEQ) and the EPA. The Project Manager prepares the specifications for, and administers the subcontracts for laboratory analysis. Mr. Banton also acts as the Quality Assurance (QA) Coordinator and, at his discretion, reviews aspects of quality control or directs Golder technical staff to perform tasks to determine if data quality objectives are being met.

Field Sampling Plan Coordinator

Michael Klisch will act as Golder's sampling plan coordinator to make contacts for appropriate scheduling, direct personnel and subcontractors in the field, collect environmental quality field samples, and to perform and report on other field operations. Mr. Klisch confers with the Project Manager and provides information to guide completion of the field tasks and to ensure all activities are conducted in accordance with the Work Plan.

Health & Safety Officer

The Health and Safety Leader Michael Klisch, is responsible for implementation of the site Health and Safety Plan (HASP) and communicating the key elements of on-site safety to the field personnel, including; personal protective measures and equipment, emergency preparedness and incident protocol.

Chemist/Validator and Site Health & Safety Coordinator

The Chemist/Validator, Mr. Tom Stapp reports to the Project Manager. He is responsible for coordinating with the subcontracted laboratories to obtain the required analyses, maintaining sample tracking, performing data validation actions and to ensure proper recording of validated data to the database. The Chemist/Validator is responsible for the review and validation of laboratory analysis reports in accordance with guidance documents available from USEPA. Mr. Stapp directs maintenance of the data files in the project database, and the generation of spreadsheets and report formats of archived data. Mr. Stapp will also act as Golder's Health & Safety Coordinator for safe and effective actions by Golder field employees.

Field Sampling Personnel

Golder Field Sampling Personnel will be selected as necessary to complete the Work Plan elements by the Golder Project Manager. The Field Sampling Personnel are responsible for safe conduct while collecting all field samples in accordance with the Work Plan and QAPP, and performance of other Technical Procedure actions as cited in Table 2-1. In addition, the Field Sampling Personnel are responsible for accumulation, organization, and maintenance of all information collected during field activities including geospatial data downloads, or sampling logbook entries (whichever is used), daily activity logbook, and chain-of-custody forms.

2.2 Use of Subcontractors

Two laboratories will be used for the geochemical characterization. The laboratories that will be used were selected based on capability, testing quality, proximity, and history with this project. They will also be responsible for analysis of groundwater quality samples collected as part of the work. Additional analytical laboratories may be used for specialized analytical services.

SVL Analytical in Kellogg, Idaho, has the capability for sample preparation and analysis of soils and solids samples, and various types of leachate analyses. Golder has experience with SVL who have provided analytical services for groundwater and surface water quality analyses for the project.

Analytical Resources Inc. located in Seattle, Washington, has performed split quality control (QC) testing for groundwater and surface water samples collected in and around the Monsanto facility.

Other laboratories may be contracted to provide specialized analytical services such as X-Ray Diffraction (XRD) or microscopic evaluations.

Each of the laboratories performs EPA Methods or Standard Methods appropriate to the analyte list as provided in Tables 2-2 and 2-3. Each laboratory holds certifications from the State of Idaho or by reciprocal agreement with other State certifications appropriate to the analytical testing identified for each laboratory in this QAPP.

3.0 DATA QUALITY OBJECTIVES

3.1 Appropriate Field Procedures & Analytical Methods

The primary objective for soil, fill, potential source area, and vadose zone material sampling is to collect representative samples these materials that will characterize the constituents of concern and evaluate potential sources of releases to the groundwater system.

Table 2-2 lists the analytical parameters of interest defined for soils, fill materials, potential source materials, and vadose zone materials sample collection during sampling activities. Table 2-3 lists the analytical parameters of interest defined for leachates. The complete list of parameters includes metal analyses using EPA 200.7 or EPA 6010B/6020B from 'Test Methods for Evaluating Solid Wastes' (USEPA 2007).

The objectives for analytical data quality are defined in terms of the quantitation limits achievable using the referenced analytical methods, and in terms of the resulting goals for precision, accuracy, representativeness, completeness, and comparability of analytical data. Quantitation limits are provided for each analytical parameter in Table 2-2 and 2-3 and are cross-referenced to an applicable standard USEPA reference method. The quality objectives established for long-term monitoring are described as follows:

- Precision: Analytical precision shall be reported on field duplicates, laboratory duplicates blank spike/ blank spike duplicates, and matrix spike/ matrix spike duplicate sample data as required by the governing reference methods cited in Tables 2-2 and 2-3. Specific precision criteria for the governing methods as required by data validation guidelines, are presented the quality control summary tables (Tables 3-1 and 3-2).
- Accuracy: Accuracy shall be reported from certified standard recovery, blank spike recovery, and matrix spike recoveries as required by the governing reference methods cited in Tables 2-2 and 2-3. Specific accuracy criteria for the governing methods as required by data validation guidelines are provided in Tables 2-2 and 2-3 and in the quality control summary tables (Tables 3-1 and 3-2).
- Representativeness: Goals for sample representativeness are addressed qualitatively by the sampling locations and intervals defined in the SAP. In addition, the use of field replicate measurements (as described in Section 4 of this QAPP) will facilitate a statistical basis for the collection of representative data.
- Completeness: Completeness is defined as the percentage of valid analytical determinations with respect to the total number of requested determinations in a given sample delivery group; Valid analytical determinations will include all data results that are not rejected (R) as a result of the data validation process described in Section 6 of this QAPP. Completeness goals are established at 90 percent. Failure to meet this criterion shall be documented in the data validation process, and corrective action taken as warranted on a case-by-case basis.
- Comparability: Approved analytical procedures shall require the consistent use of the reporting techniques and units specified by the EPA reference methods cited in Tables 2-2 and 2-3 in order to facilitate the comparability of data sets from historical and sequential sampling rounds in terms of their precision and accuracy.

4.0 SAMPLING AND OTHER FIELD PROCEDURES

4.1 Selected Procedures

Technical procedures have been developed to support sampling activities, monitoring actions, data validation, and other technical activities. Reference to technical procedures applicable to individual activities, are provided in Table 2-1, ('Technical Procedures and Quality Procedures Documents'), and complete copies for selected technical procedures are provided in Appendix B of the Work Plan. Technical Procedures are provided as guidance to technical personnel and as such, require the specific circumstance of application or the knowledge of the field scientist to appropriately apply the guidance criteria. Some technical procedures may have duplicate or similar information provided in other technical procedures that is necessary to be included to provide continuity to the content of the document. Significant changes in the field to technical procedure guidance will be identified and included on a Field Change Request form (found in: Technical Guidelines [TG] 1.2-23, "Chain of Custody") if necessary.

4.2 Material Sampling

Samples will be collected from test pits and boreholes for geochemical characterization.

4.2.1 Test Pits

Samples will be collected from test pits from the following materials:

- Native soils or fill materials.
- Any potential source materials intersected.
- Native or fill materials below any potential source materials.

The test pit depths and materials intersected will be dependent on the excavator capacity and test pit conditions (i.e. caving). Samples will be collected from the excavator bucket using a clean, stainless steel trowel or spoon and placed in appropriate sample containers. The excavator bucket will be cleaned with a shovel and brush, followed by a high-pressure water (steam) rinsing between test pits. The sampling trowel or spoon will be decontaminated with brush, Alconox wash, and distilled/deionized water rinse between each sample. The final test pit locations will be surveyed using a hand-held GPS unit.

4.2.2 Boreholes

Samples will be collected from boreholes drilled in former source areas from the following materials:

- Native soils or fill materials.
- Any potential source materials intersected.
- Any source area capping materials.
- Native or fill materials in the vadose and saturated zones below any potential source materials.

Samples will be collected as grab samples from drill cuttings discharge and split onsite. One sample split will be used to geologically log the borehole and will be archived. The second sample split will be used for geochemical characterization.

4.3 Sample Geochemical Analysis

The geochemical characterization of the soils and geologic materials, remnant source materials and vadose zone materials collected in the source area boreholes and test pits will follow a phased approach of analysis as outlined in Table 1-1. Elemental analysis will be performed on samples collected from test pits and source area boreholes along a vertical profile through the native and fill materials, source area materials, and underlying vadose zone. At a minimum, elemental analyses will be performed on one sample of each representative material from each exploration (i.e. soil and/or fill materials, potential source materials, and native materials below any sources).

Characterization of the elemental composition of a sample is typically a two-step process that includes an acid digestion to release elements into the solution phase followed by analysis of the elements in the resulting digestion. Metals analysis will be conducted following digestion as presented in USEPA Method 3050b (USEPA 1996). The analytical suites for the constituents are listed in Table 5-2 of the Work Plan.

Samples will be selected for additional characterization including leach testing and mineralogical analysis based on the type(s) and thickness of source materials intersected in the exploration, the results of the elemental analyses, and availability of previous geochemical characterization data (such as Golder 1995). Golder will prepare a technical memorandum summarizing the results of the source area explorations and elemental analyses and recommending samples for additional characterization. The memorandum will be submitted to EPA and IDEQ for review and concurrence on the proposed additional testing.

The additional geochemical characterization could include all or part of the following testing depending on the materials intersected in the explorations:

- **Leach Testing** – Leach testing will be conducted following standard USEPA protocols (i.e. SPLP and TCLP). A site-specific methodology will also be developed to evaluate leaching following interaction of vadose zone solids with site groundwater and site groundwater spiked with magnesium chloride in order to develop cadmium solubility controls. Leach test methods are listed below. The analytical suites for leachates are listed in Table 2-3.
  - **Toxicity Characteristic Leaching Procedure (TCLP)** – The TCLP leach test (Method 1311, USEPA 1992) is a regulatory test used in the classification of hazardous waste under the Resource Conservation and Recovery Act (RCRA). This test is performed at a 20:1 solution to solid ratio. TCLP testing will be performed on any materials that were not previously characterized using TCLP during the RI/FS or by Monsanto; this is anticipated to be limited to the “tailings pond” materials and any previously uncharacterized materials.

- **Synthetic Precipitation Leaching Procedure (SPLP)** – The SPLP leach test (USEPA Method 1312) (USEPA 1994) simulates the short-term interaction between meteoric water and a solid. This test is performed at a 20:1 solution to solid ratio. SPLP testing for this study will be conducted at a 4:1 solution to solid ratio to be more representative of the solution to solid ratio under site conditions.
- **Groundwater Leach Test** – Leach testing will be conducted using site groundwater and site groundwater spiked with magnesium chloride (MgCl). Testing will be conducted at a 4:1 solution to solid ratio for 18-hours (i.e. similar to the SPLP test methodology).

- **Mineralogical Analysis** – In addition to characterization of the forms in which the COCs occur in source materials, mineralogical analysis will be performed on vadose zone samples to confirm the presence, or absence, of secondary mineral phases (i.e. otavite, rhodochrosite, and fluorite). Mineralogical analysis methods will be selected based on the type of sample and may include X-ray diffraction (XRD) analysis, microscopy, or scanning electron microprobe (SEM) analysis.

4.4 Document Distribution, Variation Request, and Change Control Considerations

Variations in technical and quality procedures must be documented on a Field Change Request (FCR) form and submitted to the Project Manager for review and approval. A copy of the Field Change Request form is presented in TG-1.2-23 “Chain of Custody”, Exhibit D.

The Project Manager or his assigned Field Sampling Personnel are authorized to implement non-substantive variations based on immediate need, provided that the Project Manager is notified within 24 hours of the variation, and the FCR is forwarded to the Project Manager for review within two working days. Substantive variations require notification of the Project Manager, the Work Plan Coordinator, and Monsanto Project Manager prior to implementation, and by forwarding a FCR for review within two working days. If the variation is unacceptable to any or all of the reviewers, the activity shall be re-performed or other corrective action taken as indicated in the "Comments" section of the FCR. A copy of the FCR shall be included with all field reports, as well as the data validation report.

4.5 Sample Quantities, Types, Locations, and Intervals

Sample quantities, types, locations, and intervals for the sediment and surface soil shall be as specified in the Work Plan. Field quality control samples shall be included in the minimum quantities specified in Section 7 of this QAPP. Appropriate documentation of the sample shall include field log entries, locations of sampling units, and appropriate sample numbers assigned in sample identification records (chain of custody or better). All sample documentation shall be separately provided to the data validator. See Section 6 of this QAPP.

4.6 Sample Identification and Labeling Requirements

Sample labels will be attached to each sample container with a field sample identification number (ID) assigned to each sample collected during field activities. The number system will appear on each sample bottle or container collected and will identify a unique sample ID number applied for each sample.

The sample numbering system will ensure field QC samples will remain indistinguishable from the field locations. The label will contain the sampler's initials, one collection date, and one collection time appropriate for each sample, and will be cross referenced by the sample number to identify the location, depth, or collection detail appropriate to data recorded in the field notes. An example label is provided as follows:

Golder Associates

Sample Number:_________________________

Preservative:______________________

Analysis:______________________

Sample Date: __/ / Time: ______

Sampler: ________________________

4.7 Sample Container Type, Volume, Preservation, and Handling Requirements

All sample containers, container preparation, preservative aides, trip blank (as necessary), and sample storage chests shall be provided by the analytical laboratory as part of their agreement for services. Sample container type, volume requirements, preservation requirements, and special handling requirements are listed by analytical category in Table 4-1 for all soil, fill, bedrock, and potential source materials.

All samples shall be sealed, labeled, properly identified, and submitted to the analytical laboratory under formal chain of custody requirements as described in Section 4.8 of this QAPP. Transport sample chests will be secured with a custody seal on the outside, with signature and date provided by the attending field scientist.

4.8 Chain of Custody Considerations

All samples obtained during the course of this investigation shall be controlled as required by procedure TG-1.2-23, "Chain of Custody." Chain of custody forms (Exhibit C in TG-1.2-23) shall be completed for each shipment of samples as described in the procedure. Chain of Custody forms shall specifically identify the applicable reference methods specified in Tables 2-2 and 2-3 as appropriate for each individual sample. Sample Integrity Data Sheets (Exhibit B in TG-1.2-23) shall be completed for all sample collection locations, and cross reference the location and sample depth with the sample identification entered on the Chain of Custody. All laboratory chain of custody and sample tracking procedures shall ensure traceability of analytical results to the original samples through the analytical method referenced on the chain of custody, and the laboratory applied tracking number, which is traceable to unique sample identification numbers found on the labels as specified in Section 4.6 above.

4.9 Sampling Equipment Decontamination

Samples from test pits and boreholes will be collected using appropriately decontaminated equipment. Since all locations and samople intervals will be unique, sampling equipment will be non-dedicated.

The sampling equipment (in contact with sample) shall be thoroughly cleaned prior to beginning collection of the next sample. Personnel performing decontamination shall wear rubber gloves, safety glasses, and such other safety equipment as directed by the project-specific HASP. A summary of steps used to attain proper decontamination follows:

- Samplers and sampling tools shall be disassembled as necessary and placed in clean, dedicated buckets during and after decontamination procedures to collect wash and rinse fluids.
- For samples requiring inorganic analyses, non-dedicated equipment shall be cleaned with a brush and non-phosphate detergent - water mixture such that all visible solid matter is removed.
- A tap water or better rinse will be applied after the first detergent wash until the evidence of soap/ suds are eliminated.
- A second wash is performed on non-dedicated equipment after the first detergent/ water wash, using a fresh batch of non-phosphate detergent - water mixture.
- A second and final rinse of distilled/deionized water is then applied and the sampler is ready for use.
- If the sampler will not be used immediately, it should be stored for short term in a clean plastic bag or container to protect against ambient air contaminants.

If the non-dedicated equipment retains visible matter that is not amenable to cleaning after the previously stated actions, the equipment will be retired from the sampling procedures and not used again. Samplers shall be reassembled using clean rubber gloves.

4.10 Calibration Requirements

The testing, inspection, and maintenance of any field instruments will be performed in accordance with the manufacturer's recommendations. All field instruments and equipment used for analysis will be serviced and maintained only by qualified personnel. All repairs, adjustments, and calibrations will be documented in an appropriate logbook or data sheet that will be kept on file. The instrument maintenance logbooks will clearly document the date, the description of the problems, the corrective action taken, the result, and who performed the work.

When in use, equipment will be inspected at least twice daily, once before startup in the morning and again at the end of the work shift before overnight storage or return to the charging rack. Regular maintenance, such as cleaning of probes and lenses, replacement of in-line filters, and removal of accumulated dust, is to be conducted according to manufacturer's recommendations and in the field as needed, whichever is appropriate. All performed preventive maintenance will be entered in the individual equipment's logbook and in the site field logbook.

In addition to preventive maintenance procedures, daily calibration checks will be performed at least once daily before use and recorded in the respective logbooks. Additional calibration checks will be performed as required. All logbooks will become part of either the permanent site file or the permanent equipment file.

5.0 ANALYTICAL PROCEDURES

Tables 2-2 and 2-3 cross-references the analytes of interest of this investigation to the standard reference methods, and practical quantitation limits (PQLs or RLs). Tables 3-1 and 3-2 provide the quality control guidelines, and sample handling procedures that shall be established as contractual requirements between Golder and the subcontracted analytical laboratories. The subcontracted laboratories are responsible for implementing the analytical and sample preparation methods selected, documenting through Standard Operating Procedures (SOP) modifications (if any) to the methods, and providing these documents for review upon request. Any changes to the method number selected for analysis and identified in Tables 2-2 and 2-3 must first be brought to the attention of the Golder Project Manager in writing before analysis can commence.

The contractual requirements for PQLs and the most appropriate analytical methods are based upon historical CERCLA five-year monitoring actions, and the analytical needs associated with the work plan design.

6.0 DATA REDUCTION, VALIDATION, AND REPORTING

6.1 Minimum Requirements for Laboratory Analytical Data Packages

The laboratory selected will provide standard report formats to include elements appropriate to a 'Tier III' deliverable, including:

- Cover pages with laboratory job ID, table of contents, summary sample list and laboratory ID cross reference, laboratory narrative, and analyst/ QA manager signatures.
- Sample results in summary analytical hard copy (paper) form for each sample, with date of preparation and analysis, consistent units, analytical method ID, dilutions applied, run sequence numbers, and qualifiers as necessary.
- Analytical quality control results and summary documents for initial and continuing calibration standards, laboratory method blanks, duplicates, laboratory control samples, blank spike/blank spike duplicates, matrix spike/matrix spike duplicates, method of standard additions, serial dilutions, surrogates and internal standards.
- Sample extraction and preparation summary data including dates of sample extraction and analysis and analytical sequence information and run logs for each sample set, and each sample dilution and reanalysis.
- Chain of custody documentation, with custody signatures, sample receipt "condition found" record, noting dates of sample receipt; shipping documentation including identification of field sampling personnel, shipping personnel (or organization); and notations of variance or non-conformance as necessary.
- Electronic data diskettes or electronic deliverables that provide the summarized results, date of extraction and analysis, quality control data results and true values, client and laboratory sample identifications, analysis methods, dilutions applied and appropriate detection or reporting limits.

All data packages for all analytical parameters shall be reviewed and approved by the analytical laboratory's QA Officer prior to submittal for validation.

6.2 General Validation Requirements

All analytical data packages from each sample delivery group shall be validated by the detailed review and calculation over-check processes described in "EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review" (USEPA 2010). Selected review and validation elements of these guidance documents may not be supported by laboratory standard operating procedures for the selected methods applicable to the work. Therefore, procedures such as instrument calibration and setup identified in the selected laboratory SOP will be deferred to for proper method compliance.

Data validation guidance will be augmented in part by "Guidance on Environmental Data Verification and Data Validation; EPA QA/G-8" (USEPA 2002b). Data validation work will be performed in order to ensure that the laboratory has met all contractual requirements, all applicable reference method requirements, and has met the data quality objectives discussed previously in Section 3 and Tables 3-1 and 3-2.

Validated data will be stored as indicated in technical procedure (TP) TP-2.2-12, "Analytical Data Management" for each sample delivery group. A sample delivery group may be interpreted as a group of 20 samples, or the group of samples delivered to the laboratory in a single week, whichever occurs first.

6.2.1 Data Validation Procedures

Data deliverables will be processed by Golder Associates Inc. personnel versed in the procedures of sample receipt, data logging, deliverable review, chain of custody request confirmation, and initiation of the data validation task. According to the ‘Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use’ (USEPA 2009), the levels of validation will include electronic and manual elements from Stage 1, Stage 2A, and selected items in Stage 2B. Therefore, expected percentages associated with these levels are as follows:

VALIDATION STAGE	**REVIEW DESCRIPTION**	**LABEL CODE / Percent Applied**
Stage 1	Electronic and Manual Deliverable Receipt, Manual document review	S1VEM 10%
Stage 2A	Electronic and Manual document review, including method applicability, QC acceptance, & holding time compliance.	S2AVEM 80%
Stage 2B	Manual review of Initial and continuing calibration check compliance and recalculation	S2BVM 10%

The data validator shall document all contacts made with the laboratory to resolve questions related to the data package. The data validator shall prepare a technical report applicable for the specified method, documenting the stage of validation performed, including evaluation of laboratory blanks, field blanks, equipment blanks, duplicates, matrix spikes/matrix spike duplicates, laboratory control samples, calibration data, and any re-qualification of analytical results required as a result of the validation exercise. The validation report, laboratory contact documentation, copies of the laboratory sample summary reports, and the as-reviewed laboratory data package shall be routed to the Project Manager for data assessment purposes and to the permanent project records.

7.0 QUALITY CONTROL PROCEDURES

7.1 Field Generated Quality Control Samples

All analytical samples shall be subject to QC measures in both the field and laboratory. The following minimum field quality control requirements apply to all analyses. These requirements are adapted from *Test Methods for Evaluating Solid Waste (SW-846)* (USEPA 2007).

Field duplicates are designed to provide a separate but unique sample of the same material that was originally sampled. The original and duplicate samples are collected using the same equipment and sampling technique, and shall be placed into identically prepared containers and identically processed and tested for the purpose of assessing sampling variability. Duplicate sample locations will be selected at random. All field duplicates shall be identified with a unique sample ID number and will be processed and analyzed independently (blind) by the attending laboratory.

- ***Field duplicate samples.*** Field duplicates samples shall be collected at a minimum frequency of one for every 20 samples.
- ***Split laboratory samples.*** Split samples are used as a performance audit of the primary laboratory. At a minimum, at least one split sample will be collected for every 20 samples.
- ***Equipment blanks.*** Equipment blanks shall consist of pure deionized/ distilled commercially available water washed through decontaminated non-dedicated sampling equipment and placed in containers identical to those used for actual field samples. Equipment blanks verify the adequacy of sample containers, non-dedicated sampling equipment decontamination procedures, and the proficiency of the field technician to eliminate fugitive contaminants. Sampling will require decontamination steps between sampling units. Therefore, a minimum of one equipment blank will be generated for every 20 samples collected, or one equipment blank per sampling event, whichever is greater. The equipment blanks shall be collected at a randomly selected location.
- ***Trip blanks.*** Trip blanks will not be required of the participating laboratory, unless and until contaminants are found in batch equipment blanks with interfering quantities of analytes that cannot be explained by sampling error, or by laboratory error. If required, they shall be created and tested by the laboratory prior to shipment, accompanied with the environmental sample set, and then returned unopened to the laboratory. The use of trip blanks will be at the Project Manager's direction, and are prepared as a check on possible contamination originating from container preparation methods, shipment, handling, storage, or site conditions.

7.2 Laboratory Quality Control Samples

The internal quality control checks performed by the analytical laboratory shall meet the following minimum requirements:

- ***Matrix spike and matrix spike duplicate samples.*** Matrix spike and matrix spike duplicate samples require the addition of a known quantity of a representative analyte of interest to the sample as a measure of recovery percentage. The spike shall be made in a replicate sub-sampling of a laboratory selected field sample. Spike compound selection, quantities, and concentrations shall be described in the laboratories analytical procedures as appropriate to the analytical method. One sample shall be spiked per analytical batch, or once every 20 samples, whichever is greater, and

- ***Matrix Duplicate samples.*** Matrix duplicate analysis will be performed to identify variability with the analytical performance.
- ***Quality control reference samples (check samples).*** A quality control reference sample shall be prepared from an independent standard at a concentration other than that used for calibration, but within the calibration range. The quality control reference sample is analyzed after the initial calibration and before any samples are analyzed, and shall be run with every analytical batch, or every 20 samples, whichever is greater. Reference samples are required as an independent check on analytical technique and methodology and are described in more detail in Tables 3-1 and 3-2.
- ***Method blanks.*** Method blanks are prepared during the preparation of samples in the laboratory to determine the proficiency of the laboratory at eliminating reagent contaminants, and preparation vessel carryover contaminants. The method blank shall be prepared using the same procedure used for preparation of the samples, at the same time, and involving the same reagents. The method blank must be tested after the quality control reference sample and before any samples are analyzed, and shall be run with every analytical batch or 20 samples, whichever is more frequent.

8.0 DATA ASSESSMENT PROCEDURES

As previously discussed in Section 6, analytical data shall first be compiled by the analytical laboratory, and reduced to include the specified deliverable elements. The data will be validated by project personnel in compliance with existing validation guidelines as discussed in Section 6.2 and then reported to the Project Manager and to the Client. Data assessment will be performed on the distributions and statistical characteristics of the validated data, and will consist primarily of comparisons of the data to elements of the Record of Decision (ROD), applicable regulatory levels and historical data to assist in site characterization.

9.0 DATA MANAGEMENT

Data management involves the routing and storage of all incoming data and correspondences unique to the project activities for the purpose of security ease of access, and compliance with project goals. The following sections describe standards in place to complete the data management process.

9.1 Analytical Data Management

Laboratory data will be provided to Golder in both hard copy (paper) and electronic format. The paper copy will be routed to the data validator for confirmation of analytical data receipt and subsequent validation activities. Electronic data, by diskette, or by electronic delivery will be reserved by the data management specialist. The electronic data will include completed report copy versions in 'pdf' or facsimile form, and in spreadsheet form amenable to inclusion by electronic import to a database. Validated analytical data packages and diskettes will be routed to the project records for controlled storage and the validated data shall be processed into the analytical database in accordance with guidance found in Technical Procedure TP-2.2-12 "Analytical Data Management".

9.2 Data Review and Reporting

Following receipt and final data validation of soil and leachate results, concentrations of detected analytes will be assessed in a separate report.

10.0 SCHEDULE

The schedule for the sampling and analytical activities described in this QAPP are summarized in the Work Plan.

11.0 REFERENCES

Environmental Measurements Laboratory (EML).1997. *EML Procedures Manual, HASL-300, 28th Edition, February, 1997*. The Procedures Manual of the Environmental Measurements Laboratory; http://www.nbl.doe.gov/htm/EML_Legacy_Website/ProcMan/Start.htm

Golder Associates Inc. (Golder). 2013. Draft Work Plan for Upper Basalt Zone 2 (UBZ-2) Phase2 - Source Area Field Investigations, Monsanto Soda Springs Idaho Plant.

United States Environmental Protection Agency (USEPA). 2002a, EPA *Guidance for Quality Assurance Project Plans*, EPA QA/R-5, (EPA/240/R-02/009), December.

USEPA. 2002b. G*uidance on Environmental Data Verification and Data Validation*; EPA QA/G-8, EPA/240/R-02/004, November.

USEPA. 2007. *Test Methods for Evaluating Solid Waste, Third Edition, Revision 6*, (SW-846), February.

USEPA. 2009. '*Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use*', OSWER No, 9200.1-85, EPA 540-R-08-005, January 13, 2009.

USEPA. 2010. *USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Data Review, Final*, EPA-540/R-00-006, January.

TABLES

Table 1-1: Sample Collection Summary

Exploration Type	Material Sampled	Number of Samples per Exploration[a]	Total Number of Analyses			
			Elemental Analysis	Leach Testing[b]	Mineralogical Charaterization[b]	Water Quality Analysis
Test Pits (7 test pits)	Soil/Fill materials	1	7	na	na	na
	Source materials	2	14	14	14	na
	Native materials below sources	2	14	14	14	na
Source Area Boreholes (4 boreholes)	Soil/Fill materials	1	4	na	na	na
	Cap materials	2	8	na	8	na
	Source materials	4	8	8	8	na
	Native materials below sources	3	8	8	8	na
Monitoring Wells (9)	Groundwater	1	na	na	na	9

Note

a. Actual number of samples per exploration dependent on materials intersected at each location.
b. Samples for leach testing and mineralogical analysis to be selected based on elemental analysis results, types and thickness of materials intersected, and previous characterization data, and concurrence of EPA and IDEQ.
c. na: Not analyzed

Table 2-1: Technical Procedures and Quality Procedure Documents

TG-1.2-23	Chain of Custody
TP-1.2-18	Sampling Surface Soil for Chemical Analysis
TP-2.2-12	Analytical Data Management

Table 2-2: Analyte List

Test Type	Analytical Parameter	Proposed Test Methods[1]	Reporting Limits (mg/kg)	Method Detection Limits (mg/kg)
Geochemical Characterization (elemental analysis)	Aluminum	EPA 6010B	8.0	2.5
	Arsenic	EPA 6010B or 6020B	2.5	0.5
	Cadmium	EPA 6010B or 6020B	0.2	0.034
	Calcium	EPA 6010B	4.0	1.5
	Chromium	EPA 6010B or 6020B	0.6	0.065
	Iron	EPA 6010B	6.0	1.9
	Lead	EPA 6010B or 6020B	0.75	0.25
	Magnesium	EPA 6010B	6.0	1.9
	Manganese	EPA 6010B or 6020B	0.4	0.16
	Molybdenum	EPA 6010B or 6020B	0.8	0.075
	Nickel	EPA 6010B or 6020B	1.0	0.31
	Potassium	EPA 6010B	50	15
	Selenium	EPA 6010B or 6020B	4.0	0.82
	Silicon	EPA 6010B or gravimetric	na	na
	Sodium	EPA 6010B	50	2.3
	Strontium	EPA 6010B	0.5	0.034
	Zinc	EPA 6010B or 6020B	1.0	0.16
	Sulfur (total)	LECO	0.01 %	0.01%

Table 2-3: Leachate Analyte List

Test Type	Analytical Parameter	Proposed Test Methods	Reporting Limits (mg/L except as noted)	MDL (mg/L)
Leach Testing (TCLP-EPA 1311, SPLP-EPA 1312 and Groundwater Leaching)	pH	EPA 9045D	na	na
	Conductivity	SM 2510B	5 μmhos/cm	na
	Total Dissolved Solids	SM 2540C	10	na
	Chloride	EPA 300.0	1	0.061
	Sulfate	EPA 300.0	1.5	0.066
	Alkalinity	SM 2320B	1	1
	Nitrate	EPA 300.0	0.25	0.015
	Fluoride	EPA 300.0	0.5	0.017
	Aluminum	EPA 200.7 or 6010B	0.080	0.023
	Arsenic	EPA 200.7 or 6010B	0.025	0.0068
	Cadmium	EPA 200.7 or 6010B	0.002	0.0007
	Calcium	EPA 200.7 or 6010B	0.040	0.015
	Chromium	EPA 200.7 or 6010B	0.006	0.0007
	Iron	EPA 200.7 or 6010B	0.060	0.019
	Lead	EPA 200.7 or 6010B	0.0075	0.0034
	Magnesium	EPA 200.7 or 6010B	0.060	0.022
	Manganese	EPA 200.7 or 6010B	0.004	0.0014
	Molybdenum	EPA 200.7 or 6010B	0.008	0.0018
	Nickel	EPA 200.7 or 6010B	0.010	0.003
	Potassium	EPA 200.7 or 6010B	0.5	0.14
	Selenium	EPA 200.7 or 6010B	0.040	0.011
	Silicon	EPA 200.7 or 6010B	0.171	0.051
	Sodium	EPA 200.7 or 6010B	0.5	0.11
	Strontium	EPA 200.7 or 6010B	0.005	0.0011
	Zinc	EPA 200.7 or 6010B	0.010	0.003
	Sulfur (total)	na	A	A

Notes:
A – Sodium and sulfur not tested in extracts.
na – Analysis typically not performed on procedural extracts.

Table 3-1: Quality Control Summary, Metals Analyses

Parameter	Description
Method Reference	EPA 6010B / 6020B, SW-846 Test Methods for Evaluating Solid Wastes, February, 2007.
Matrix	Soils, fill materials, potential source area materials.
Analytes	As indicated in Table 2-2 and 2-3.
Holding Time	As indicted in Table 4-1.
Laboratory Instrument Calibration	ICP: A blank and at least one calibration standard. The low level standards must be analyzed at the method specified concentration at the required frequency.
Laboratory Method Blank	Blank sample is analyzed for each analyte parameter and no analytes should be found in the blank. At least one preparation blank d(method blank) must be prepared for each matrix per 20 field samples or each batch whichever is more frequent. If any analyte concentration in the preparation blank is above the reporting limit or the method detection limit, the lowest concentration of that analyte in the associated sample must be 10 times the concentration in the blank.
Equipment Blanks	Equipment blanks will be collected at a minimum frequency of one per each set of twenty samples collected, for each type of collection device used. Distilled water or laboratory supplied water will be rinsed over each collection device used, and stored in collection containers also reserved for soil.
Laboratory QC Check Standards	ICP initial calibration verified with independent standard %R 90-110. Digest an independent LCS with each sample batch for ICP if available %R 80-120.
Duplicate Sample	Field duplicates are scheduled to be collected at a minimum frequency of one per each set of twenty samples collected. Each is prepared as a blind field duplicate. Relative percent differences (RPD) between field duplicates are advisory only; ≤35% for soil samples. (MS/MSD checked for RPD also).
Laboratory Matrix Spike/ Matrix Spike Duplicate Sample	Analyze spiked field sample at frequency of one per twenty samples or each batch, whichever is more frequent for soil samples. Percent recovery (%R) between 80-120%. Method of standard additions may be applied if interference is indicated.

Table 3-2: Quality Control Summary, Other Leachate Analytes

Parameter	Description
Method Reference	Test Methods for Evaluating Solid Waste; SW-846, (EPA 2007) Methods for Chemical Analysis of Water and Wastes, (EPA 1983) Standard Methods for Examination of Water and Wastewater, (APHA 2007)
Matrix	Surface soil, Sediment
Analytes	Metals lists and General Chemistry parameters as indicated in Tables 2-2 and 2-3
Holding Time	As indicated in Table 4-1.
Laboratory Instrument Calibration	A blank and at least three calibration standards for spectrophotometer, and anion analysis. One standard must be analyzed at or near the method reporting limit. Verify calibration prior to sample analysis, every twenty samples and at the conclusion of sample analysis. Balance check with NIST traceable standard weight for TDS analysis.
Laboratory Method Blank	Blank sample is analyzed at each analyte parameter and no analytes should be found in the blank. At least one preparation blank must be prepared for each matrix per 20 field samples or each batch whichever is more frequent. If any analyte concentration in the preparation blank is above the reporting limit, the lowest concentration of that analyte in the associated sample must be 10 times the concentration in the blank.
Laboratory QC Check Standards	Initial calibration verified with independent standard %R 90-110, with the exception of TDS. Digest an independent LCS with each sample batch for each matrix if available, acceptable %Recovery 80-120.
Laboratory Matrix Spike/ Matrix Spike Duplicate Sample	Analyze spiked leachate at frequency of one per twenty samples or each batch, whichever is more frequent. Percent recovery (%R) between 80-120%. Use method of standard additions as necessary if interference is indicated.
Other Laboratory QC Criteria	Verify linear ranges quarterly. Results must be within ±5% of true value. All measurements minimum of 2 replicate exposures, report average. Serial dilution analysis performed if concentration is 50X limit, must agree ±10% of the original value.

Table 4-1: Soil, Source, and Vadose Zone Sample Container Types, Volumes, Handling, Preservation, and Holding Times

Test Type	Analytes	Analytical Method	Container Type [a]	Special Handling	Preservation	Maximum Holding Time
Geochemical Characterization	Total Metals:(Al, As, Cd, Ca, Cr, Fe, Pb, Mn, Mg, Mo, Ni, K, Se, SiO2, Na, Sr, Zn)	EPA 6010B/ 6020B	1, 8-oz soil jar	Fill to neck	None, store at 6°C and below	180 days
	Sulfur	LECO	Metals container	Metals container	Metals container	180 days
Leach Testing (TCLP, SPLP, Groundwater Leaching)	Total Metals:(Al, As, Cd, Ca, Cr, Fe, Pb, Mn, Mg, Mo, Ni, K, Se, SiO2, Na, Sr, Zn)	EPA 200.7 or 6010B	1, 1,000 mL wide mouth polyethylene bottle.	Need 500 g material	Store at 6° or below, adjust pH to <2 for metals in leachate	180 days from collection to extraction; 180 days from extraction to analysis.
	Anions (Cl, SO_4 F)	EPA 300.0	Laboratory selected	NA	Store at 6° and below	28 days from extraction to analysis.
	pH	EPA 9045D	Laboratory selected	NA	Store at 6° and below	Immediate for procedural monitoring.
	Conductivity	SM 2510B	Laboratory selected	NA	Store at 6° and below	Immediate for procedural monitoring.
	Nitrate – N	EPA 300.0	Laboratory selected	NA	Store at 6° and below	28 days from extraction to analysis.
	Total Alkalinity	SM 2320B	Laboratory selected	NA	Store at 6° and below	14 days from extraction to analysis.
	Total Dissolved Solids	SM 2540C	Laboratory selected	NA	Store at 6° and below	7 days from extraction to analysis.

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Inc.
18300 NE Union Hill Road, Suite 200
Redmond, WA 98052 USA
Tel: (425) 883-0777
Fax: (425) 882-5498

Golder Associates